System Impact Study
For
Soveren, Inc
Westminster Business Park
Westminster, VT 05159

500 kW Three-Phase, Inverter Based Photovoltaic Generation

Interconnection to Green Mountain Power's 12.47 kV System

GREEN MOUNTAIN POWER

Generating Possibilities Together

Table of Contents

Section Page

Tables

Table Page

Table of Figures

Figure Page

Appendixes

Executive Summary

ControlPoint Technologies (CPT) working with Green Mountain Power (the "Company") has completed the System Impact Study, for the interconnection of the Soveren, Inc, ("Interconnecting Customer" or "IC"), 500 kW (AC) PV Facility, ("the Facility"), to its 12.47kV distribution system, ("the Project"), and presents the conclusions of the study herein. The requirements specified are exclusive to this project and are based upon the information submitted by the Interconnecting Customer at the time the Interconnection Application ("IA") was submitted. Any further design changes made by the Interconnection Customer post IA without the Company's and CPT's knowledge, review, and/or approval will render the findings of this report null and void.

The Facility will be located at Westminster Business Park, Westminster, VT, 05159 and interconnect to Green Mountain Power's electric power system via the Company's 12.47 kV distribution circuit 74G2, at taglet 38384, Route 5, which will be known as the "Point of Interconnection, ("POI"). The 74G2 originates from the Westminster Substation #74. The interconnection point itself is operated at 8.32 kV.

<u>The purpose of this study was to</u>:

- Conduct, as applicable, steady-state, stability, short circuit, and extreme contingency analyses and perform assessments of reliability performance of the Company's Electric Power System ("EPS") within the area of interconnection, with and without the proposed Facility, in accordance with applicable reliability standards and study practices, and in compliance with the applicable codes, standards, and guidelines referenced in Vermont Public Service Board's Rule 5.500 to determine the incremental impact and any potential adverse impacts associated with the interconnection of the Facility to the EPS.

- Determine any system modifications required.

- Evaluate the existing distribution protection scheme to ensure that there is no degradation of reliability to Green Mountain Power's customers.

- Provide a report describing the results of the System Impact Study.

The study determined what modifications will be required to be made to the Company's EPS and operating procedures before the Project can proceed to interconnect:

The required EPS modifications include, but are not limited to, the following:

- An overhead line extension including a disconnect switch, will be required between the POI and the Point-of-Common-Coupling (PCC).
- Installation of three-phase overhead transformer bank.

The project should not have a negative impact on system voltage, under normal operating conditions. For the most extreme case, the maximum voltage change for the facility's on/off switching is 1.2%. The study indicates that the Facility should not cause noticeable flicker.

The interconnection requester is responsible to provide and maintain a relayed breaker with per phase overcurrent elements set for instantaneous operation for 125% of rated phase to neutral voltage. In addition, the relay shall be set with 81U, 81O, 27 elements redundant to the inverter protection settings and conforming to IEEE 1547.

The study indicates that the proposed design is effectively grounded when connected to the area EPS in all instances. The circuit also has one farm based methane generator connected and a second planned for interconnection. The study indicates that the project does not create any thermal issues to the area EPS.

Station Modifications will be required at the Westminster Distribution Substation. Due to the likelihood of reverse power flow onto the 69 kV transmission system, the transmission owner, National Grid, will require installation of three phase potential transformers on the 69 kV bus. The PT's will support $3V_0$ protection at the station. The substation regulator control settings must be reconfigured to lock forward once reverse flow is sensed on the distribution.

If an event occurs with a recorded over-voltage at the PCC exceeding limitations and/or any reported damage of customer equipment, The Company reserves the right to disconnect the Project from the EPS. The developer will be responsible for all associated claims and for mitigation to prevent re-occurrence. In this instance, The Company could require a Direct Transfer Trip (DTT) scheme from all upstream feeder sectionalizing devices to a PCC recloser.

It should also be noted that it may not be possible for the Company to keep the Project connected during feeder backup scenarios. Reasonable attempts shall be made to keep the Project on during feeder backup. If it is found that DTT is a requirement for normal operation of this Project, then an additional DTT would need to be installed, at customer cost, on the feeder backup circuit to allow the Project to run during feeder backup.

The following documents and references pertain to this project:

Vermont Public Service Board Rule 5.500
IEEE 1547 – 2003 --IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems

IEEE 1547.3 --IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected to Power Systems
IEEE 1453-2004 --IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems
ANSI C 84.1-2006 American National Standard for Power Systems and Equipment Voltage Ratings (60 Hz)
IEEE Standard C37.90.1-2002 Standard Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

1.0 Introduction

Soveren, Inc has requested a Distributed Generation interconnection for a 500 kW (AC) Photovoltaic System to a distribution feeder in the Company's EPS. The Interconnection Customer's proposed In-Service date included in the Interconnection Application dated February 13, 2013, is December 1, 2013, but this date is not binding.

In accordance with the P.S.B. Rule 5.500, the Company has completed a System Impact Study to determine the scope of the required modifications to its EPS and/or the Facility for providing the requested interconnection service.

1.1 Study Objective

The primary objectives of this Impact Study are to:

1. Identify the System Modifications necessary for the Project to reliably interconnect to the Company's system;
2. Identify deficiencies in the proposed Facility;
3. Identify operating restrictions;

2.0 Project Description

2.1 Facility

As depicted in the Interconnecting Customer's PV Layout Drawing and One Line Diagram, *refer to **Figures 1, 2 & 3**, respectively*, the three-phase 500 kW AC generating system will consist of the following:

- Twenty (20) banks Renesola JC300M-24AB Solar Modules. Each bank will consist of tens (10) strings of nine (9) modules connecting to a DC combiner panel.
- Each DC combiner box will connect to a 24 kW Refusol 024k-UL inverters.
- One (1) bank of Renesola JC300m-24AB Solar Modules. This bank will consist of four (4) strings of eight (8) modules connecting to a DC combiner panel.
- This DC combiner panel will connect to a single Refusol 012K-UL Inverter.
- The project incorporates 21 inverters.
- The output of the inverters is connected to two (2) three-phase, 480/277 V AC panels. Each inverter is connected through a 35 Amp breaker.
- The AC panels output will connect to a 400 Amp fuse compartment and then to a 480/277 Volt meter. The line-side of the meter will connect via 600 Volt underground cable to a pole-mounted transformer bank.
- The transformer bank will be a Wye-Wye connection of 3 – 167 kVA 8.32/4.8 kV to 480/277 Volt single phase transformers.
- The Point-Of-Interconnection (POI) will be at taglet 38384 Westminster Road. This pole will be framed for three-phase junction.
- The overhead line will extend to the low-voltage bushings on the transformer bank.

The Generator Step-up Transformers (GSU) are listed correctly for the existing service voltage of 4.8/8.32 kV. Transformers with a dual primary voltage rating of 4.8/8.32 kV x 7.2/12/47 kV will be installed to facilitate future voltage conversion projects under consideration.

2.2 Service Configuration

The proposed location of the Facility is normally served by Green Mountain Power's 7.2/12.47 kV wye-grounded distribution line 74G2 from the Westminster Distribution substation. The 74G2 circuit, at the Point-Of-Interconnection (POI), has a delivery voltage of 4.8/8.32 kV. GMP has identified future conditions that will require a system voltage conversion. All overhead and underground equipment installed for this project should be built per GMP's 7.2/12.47 kV construction standards.

Based on the Project design at the time the study was performed, the Interconnection Facilities will be paid for by the Customer but owned and maintained by the Company, and shall consist of:

- A new three phase tap from the existing 3 phase primary on Westminster Road, taglet 38384, (POI).
- A set of cutout style disconnects for use as a visual open point.
- A Pole-mounted three phase transformer bank.

An interconnection one-line diagram is shown in Figure 4.

2.3 Westminster Substation

The Westminster Distribution substation is fed from a radial tap off the National Grid 69 kV line circuit between Bellows Falls Station to the north and Ferry Road Station to the south. The tap is between switches 334 and 33P.

The 69 kV transmission circuit is connected through switch #691 at Westminster Substation. Switch #691 feeds a set of 200 Amp fuses that provide high-side transformer protection. The fuses connect to a single 14 MVA, 67kV Δ – 4800/8320 x 7560/13090V station transformer. The transformer no-load-tap changer is set to the tap #A, the 70.3 kV tap.

The station transformer supplies outdoor switchgear consisting of a 12.47 kV bus with two distribution circuits, the 74G1, and the 74G2. Each of these circuits is protected by Cooper Form 6 VWE circuit reclosers. The relays provide overcurrent and ground overcurrent detection. The distribution circuits are also equipped with reclosing relays.

A one-line diagram of Westminster Substation is shown in Figure 5.

2.4 Area EPS

The proposed location of the Facility is normally served by Green Mountain Power's 7.2/12.47 kV three-phase, 4-wire, multi-grounded wye, effectively-grounded 74G2 radial circuit from the Westminster Distribution Substation, *refer to* Figure 6: Westminster 74G2/67G2 One Line. The 74G2 circuit characteristics are as follows:

- Voltage regulated by three (3) single-phase feeder voltage regulators installed at the #74 Westminster Distribution Substation. Mainline voltage is supported by two (2) additional sets of line regulators. Regulator location and settings are shown in Table 1 below.

Device Number	Distance (ft)	Bandwidth (V)	CT Ratio	V Float	R	X	Delay (sec)
Station REGS	**0**	**± 1.5**	**600**	**124**	**0**	**0**	**30**
Station REGS	**0**	**± 1.5**	**600**	**124**	**0**	**0**	**30**
Station REGS	**0**	**± 1.5**	**600**	**124**	**0**	**0**	**30**
Taglet 77792	9,000	± 1.5	100	124	0	0	45
Taglet 77793	9,000	± 1.5	100	124	0	0	45
Taglet 77794	9,000	± 1.5	100	124	0	0	45
Taglet 38897	**29,500**	**± 1.5**	**100**	**124**	**0**	**0**	**60**
Taglet 38897	**29,500**	**± 1.5**	**100**	**124**	**0**	**0**	**60**
Taglet 38897	**29,500**	**± 1.5**	**100**	**124**	**0**	**0**	**60**

Table 1: Voltage Regulators

- There is one (1) mainline pole-mounted recloser;
    - Taglet 38337, Pole 78, – upstream of the Facility. The recloser provides high-side protection of a large stepdown area.

- There is a three stepdown transformer bank located at pole 80, Taglet 180636. The bank consists of three 500 kVA single phase transformers connected wye-gnd/wye-gnd. The transformers are rated 7.2/12.47 kV – 4.8/8.32 kV.

- There is one (1) three-phase capacitor bank on the 74G2 circuit. It is a 300 kVAR bank, manually controlled and located at Taglet 38540. It is located on the 4.8/8.32 kV distribution system.

- There are two single phase capacitors on the 4.8/8.32 kV. Both are fixed 100 kVAR capacitors. One is at Taglet 38148 and connected to A Phase. The second is at Taglet 39189 and is connected to C Phase.

- Load Data was analyzed for the period September 30, 2011 through October 1, 2012. The Westminster Station Load Data was combined with the Goodell generation data to derive circuit loads on the 74G2.

- Based on this analysis, the 74G2 had a maximum load of approximately 1.43 MVA, at a power factor of 99.3%, during the period of peak generation, (10AM – 4PM).

- The 74G2 had a minimum load of 0.503 MVA, at a power factor of 92.5%, during periods of peak generation. During periods of maximum generation, reverse power flow can be expected through the 74G2 circuit breaker.

- The minimum 12.47 kV bus loading at Westminster was 0.93MVA. With all connected and proposed generation running it is anticipated that this bus will see reverse power flow onto the 46 kV transmission system.

- In addition to the proposed 500 kW project, there is an additional 321 kW of inverter connected solar generation on the 74G2 circuit.

- There is one farm based methane synchronous generator connected to the 74G2 circuit, with a second identical generator planned for the same location, Goodell Farm.

- The Goodell generation consists of two 225 kVA synchronous generators (one installed and one planned) capable of producing 450 kW. These units will be equipped with Direct Transfer Trip (DTT).

- The total projected/installed distributed generation capacity on the 74G2 is 1.27 MW.

- The 74G2 circuit has feeder ties with the 67G2 at Pole 70, Taglet 180510.

- Coincident load data was not available for the 74G2 and the 67G2 circuits. Using SCADA data from 9/30/2012 through 10/1/2013, the 67G2 had a peak load of 1.07 MVA on 7/20/2013.

- The 67G2 had a minimum load of 0.39 MVA on 5/20/2013. This minimum occurred during the period of expected peak generation.

2.5 Monitoring Provisions

Per IEEE section 4.1.6 Monitoring Provisions, each Distributed Resource (DR) unit of 250 kVA or more or DR aggregate of 250 kVA or more at a single PCC shall have provisions for monitoring its connection status, real power output, reactive power output, and voltage at the point of DR connection. The project plans to install 500 kW (AC) of PV generation, therefore monitoring provisions would be required. The Company intends to meet this requirement through bi-directional metering installed at the Point of Common Coupling (PCC).

3.0 Analysis

Westminster Station load levels were provided in 60 minute intervals. Loading for the 74G2 and 74G1 was derived from SCADA load data. The Goodell generation data was provided in 15 minute intervals. The 15 minute interval data was used to create an hourly average generation value. The Goodell generation data was combined with the station meter readings to provide an adjusted circuit load. The results of this analysis for Maximum load conditions are shown in Table 2 and Table 3. The minimum load conditions are shown in Table 4 and Table 5.

Maximum Load[1] without Soveren, Inc Generation				
Circuit Element	Data Source	MVA	MW	MVAR
Westminster Station	SCADA	2.19	2.19	0.13
74G2	SCADA	1.14	1.13	0.12
74G1	SCADA	1.06	1.06	0.01
67G2	**SCADA**	**1.07**	**1.032**	**0.27**

Table 2: Maximum Load w/o Generation

Projected Maximum Load with Soveren, Inc Generation				
Circuit Element	Data Source	MVA	MW	MVAR
Westminster Station	SCADA	1.72	1.69	0.33
74G2	SCADA	0.65	0.63	0.14
74G1	SCADA	1.06	1.06	0.01

Table 3: Maximum Load with Generation

Minimum Load without Soveren, Inc Generation				
Circuit Element	Data Source	MVA	MW	MVAR
Westminster Station	SCADA	0.93	0.89	0.28
74G2	SCADA	0.45	0.43	0.14
74G1	SCADA	0.45	0.43	.14
67G2	**SCADA**	**0.39**	**0.36**	**0.15**

Table 4: Minimum Load w/o Generation

Projected Minimum Load with Soveren, Inc Generation				
Circuit Element	Data Source	MVA	MW	MVAR
Westminster Station	SCADA	0.45	0.36	0.28
74G2	SCADA	0.16	-0.07	0.14
74G1	SCADA	0.45	0.43	.14

Table 5: Minimum Load with Generation

[1] Includes 321 kW of Distributed PV Generation – All Cases

The Goodell generator data analyzed does not reflect the addition of a second 225 kW farm based methane generator. This adjustment will reduce the 74G2 by 0.365 MW. Table 6 and 7 show the expected load levels with both Goodell generator units operating at 100% nameplate and a unity power factor. With all generation running, the analysis indicates reverse power flow at periods of minimum load.

Minimum Load without Soveren, Inc Generation				
Circuit Element	Data Source	MVA	MW	MVAR
Westminster Station	SCADA	0.56	0.49	0.28
74G2	SCADA	0.16	0.06	0.14
74G1	SCADA	0.45	0.43	.14
67G2	**SCADA**	**0.39**	**0.36**	**0.15**

Table 6: Minimum Load with Goodell Generators at 100%

Projected Minimum Load with Soveren, Inc Generation				
Circuit Element	Data Source	MVA	MW	MVAR
Westminster Station	SCADA	0.29	-0.1	0.28
74G2	SCADA	0.16	-0.44	0.14
74G1	SCADA	0.45	0.43	.14

Table 7: Minimum Load with Goodell Generators at 100%

The power flow analysis was substantially performed using CYMDIST. A model of the Westminster distribution lines was developed based on data supplied by Green Mountain Power.

The analysis considered cases at minimum and peak load on the distribution line 74G2 at the time of expected maximum generation. Each case was analyzed with any previously approved distributed DG resource on and at unity power factor. The generator status and generator power factor were varied as listed in Table 6. The generator under study refers to the Soveren, Inc status. The following Load Flow Studies were performed on the Westminster Distribution circuit 74G2:

Feeder	Goodell Generator	Feeder Load	Feeder Power Factor	Generator Under Study Status	Generator Power Factor
74G2	OFF	MAX\MIN	99.3%\92.5%	Off	NA
74G2	OFF	MAX\MIN	99.3%\92.5%	On	100%
74G2	OFF	MAX\MIN	99.3%\92.5%	On	99% (Leading)
74G2	OFF	MAX\MIN	99.3%\92.5%	On	99% (Lagging)
74G2	ON	MAX\MIN	99.3%\92.5%	Off	NA
74G2	ON	MAX\MIN	99.3%\92.5%	On	100%
74G2	ON	MAX\MIN	99.3%\92.5%	On	99% (Leading)
74G2	ON	MAX\MIN	99.3%\92.5%	On	99% (Lagging)

Table 8: Load Flow Cases

The study considered the feeder back-up cases for the 74G2 on 67G2. The following Load Flow Studies were performed for this feeder back-up contingency.

Feeder	Goodell Generator	Feeder Load	Feeder Power Factor	Generator Under Study Status	Generator Power Factor
74G2 on 67G2	OFF	MAX\MIN	98.4%\92.6%	Off	NA
74G2 on 67G2	OFF	MAX\MIN	98.4%\92.6%	On	100%
74G2 on 67G2	OFF	MAX\MIN	98.4%\92.6%	On	99% (Leading)
74G2 on 67G2	OFF	MAX\MIN	98.4%\92.6%	On	99% (Lagging)
74G2 on 67G2	ON	MAX\MIN	98.4%\92.6%	Off	NA
74G2 on 67G2	ON	MAX\MIN	98.4%\92.6%	On	100%
74G2 on 67G2	ON	MAX\MIN	98.4%\92.6%	On	99% (Leading)
74G2 on 67G2	ON	MAX\MIN	98.4%\92.6%	On	99% (Lagging)

Table 9: 74G2 on 67G2 Load Flow Cases

The feeder back-up case for the 67G2 on 74G2 was also analyzed. The following Load Flow Studies were performed for this feeder back-up contingency.

Feeder	Goodell Generator	Feeder Load	Feeder Power Factor	Generator Under Study Status	Generator Power Factor
67G2 on 74G2	OFF	MAX\MIN	98.4%\92.6%	Off	NA
67G2 on 74G2	OFF	MAX\MIN	98.4%\92.6%	On	100%
67G2 on 74G2	OFF	MAX\MIN	98.4%\92.6%	On	99% (Leading)
67G2 on 74G2	OFF	MAX\MIN	98.4%\92.6%	On	99% (Lagging)
67G2 on 74G2	ON	MAX\MIN	98.4%\92.6%	Off	NA
67G2 on 74G2	ON	MAX\MIN	98.4%\92.6%	On	100%
67G2 on 74G2	ON	MAX\MIN	98.4%\92.6%	On	99% (Leading)
67G2 on 74G2	ON	MAX\MIN	98.4%\92.6%	On	99% (Lagging)

Table 10: 67G2 on 74G2 Load Flow Cases

3.1 General Loading Analysis

An analysis of the feeder loading, with and without the PV system, was performed and demonstrated that the addition of the Facility will not create thermal loading problems on the 74G2, Westminster Distribution Substation. Specifically, no conductor, or transformer overloads occur. All Green Mountain Power owned mainline conductor and distribution facilities are thermally large enough to accommodate the added capacity from the 500 kW PV facility.

3.2 Voltage Analysis

Per IEEE 1547 Section 4.1.1 Voltage regulation, The DR shall not actively regulate the voltage at the PCC. The DR shall not cause the Area EPS service voltage at other Local EPSs to go outside the requirements of ANSI C84.1-1995, Range A. Range A of the ANSI standard requires the Company to hold voltage within +/- 5% of nominal at the customer service point under normal operating conditions with the system generation at full power. The Customer must maintain voltage at the PCC at +/- 5% of nominal under normal conditions.

The impact of this proposed generation was carefully reviewed for this site. In summary, there are no reports of over-voltage conditions on the Company's EPS with the generation interconnection site at full power during studied cases while connected to the 74G2 under normal conditions, refer to Figure's 7 - 10. These four cases analyzed the impact of the proposed Soveren, Inc PV during maximum and minimum loading conditions with the existing synchronous generators interconnected and disconnected.

For the case with synchronous generators operating at rated output and a power factor of 100%, the output of the PV facility was modeled at full power output at unity power factor, a 99% leading power factor and a 99% lagging power factor. The results of this analysis are shown in Figures 7 and 8. The largest voltage change on the 74G2 was a 1.0% rise in voltage at the PCC. There were no instances of out-of-range voltages in this analysis

A similar analysis was completed with the existing synchronous generators disconnected. The output of the PV facility was modeled at full power output with a unity power factor, a 99% leading power factor and a 99% lagging power factor. The results of this analysis are shown in Figures 9 and 10. The largest voltage change on the 74G2 was a 1.2% rise in voltage at the PCC. There were no instances of out-of-limit voltages in this analysis

The same analysis was conducted for the Feeder Back-up case of the 74G2 on the 67G2. Figures 11 and 12 contain the results of this analysis for the Goodell generator's operating at 450 kW and a unity power factor. The maximum rise in voltage was 1.6% at the PCC. Figures 13 and 14 contain the results of this analysis for the cases with the Goodell generator disconnected. There were no instances of out-of-limit voltages in this Feeder Back-up analysis.

Similarly, the Feeder Back-up case for the 67G2 on the 74G2 was considered. Figures 15 and 16 contain the results of this analysis for the Goodell generator's operating at 450 kW and a unity power factor. The maximum rise in voltage was 1.2% at the PCC. Figures 17 and 18 contain the results of this analysis for the cases with the Goodell generator disconnected. There were no instances of out-of-limit voltages in this Feeder Back-up analysis.

3.3 Flicker Analysis

The IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems, IEEE Std. 1453-2004 provides guidance on flicker and voltage fluctuations.

An analysis for this impact study was conducted using the long-term dynamic modeling capability of Cyme. The intent was to determine the frequency and magnitude of the voltage changes caused by a varying output from the Facility. Using 5 second output data from an existing GMP solar facility and the available 60 minute load data, we created generation curves and load curves as inputs into the Cyme model. The generator output data was reviewed to identify the 2 hour period with the greatest variation in output. This 2 hour output was duplicated to create a 6 hour generator curve. The output curve was expanded to create one second data points by filling the intervals between readings with the previous value.

The load data was refined by adding an interim reading for each 60 minute interval. This interim reading was recorded at the midpoint of the interval and was derived by using the midpoint value between successive readings. This produced a stepped load curve that was constant for each 30 minute interval. This method will tend to smooth the effects of changing load.

Using a six hour simulation time, the 74G2 circuit was modeled using the long-term dynamic model. The analysis monitored the voltage at the substation, the low-side of the stepdown transformer bank, the load side of the downstream regulators, Taglet 77792, and at the PCC. The analysis was then run with maximum and minimum load values for a generator output at power factors of 100%, +99% and -99%. The existing synchronous generators were disconnected for this analysis. As expected, the maximum load cases presented the highest flicker levels. A flicker event describes a change in voltage greater than 0.4% in magnitude during any one second interval of the dynamic modeling analysis.

Figure 19 summarizes the results during maximum load with the Facility operating at a varying output at unity power factor. The voltage at the PCC did not exceed ANSI A limits. The maximum voltage fluctuation recorded was 0.33%. This analysis did not indicate any flicker events.

Figure 20 is a voltage profile of the PCC for the case described above. The simulation did not raise concern for noticeable flicker.

The steady state analysis indicated a maximum change in voltage of 1.2% when the Facility is suddenly switched on. Based on the GE flicker curve, see Figure 21, a flicker level of this magnitude would need to occur ten times per minute to exceed GMP limits. The clouded region represents the level of the maximum ΔV. This level is slightly above the threshold of visibility.

The same analysis was conducted with the Facility output operating at a +99% power factor. The resultant flicker analysis is shown in Figure 22. The voltage at the PCC did not exceed ANSI A limits. The maximum voltage fluctuation recorded was 0.33%. This analysis did not indicate any flicker events.

The same analysis was conducted with the Facility output operating at -99% power factor. The resultant flicker analysis is shown in Figure 23. The voltage at the PCC did not exceed ANSI A limits. The maximum voltage fluctuation recorded was 0.41%. This analysis did not indicate any flicker events.

The fluctuating output of the Facility will affect the frequency of operation of the regulator tap changers. Table 9 below summarizes the regulator performance during the 6 hour simulation. The regulators at the substation and nearest the PCC will experience the most operations. The tap range is relatively narrow. The regulator tap changing mechanism is rated for thousands of operations. If the regulator maintenance reports indicate excessive wear, an adjustment to the settings could be required.

Device Number	Phase	Tap Change Count	Minimum Tap	Maximum Tap	Average Tap
77793_38389_36	A	0	4	4	4
77793_38389_36	B	3	3	4	3
77793_38389_36	C	0	2	2	2
38897_38898_42	A	7	5	7	5
38897_38898_42	B	22	4	6	4
38897_38898_42	C	0	1	1	1

Table 11: Regulator Tap Changes

Interconnection of the Facility should not create noticeable flicker to customers served from the 74G2. There were no findings of flicker likely to cause customer irritation. The Facility will affect the frequency of regulator tap changes. The effects of the increased frequency of operation will need to be monitored.

3.4 Reverse Power Flow

The minimum loading on the #74 Westminster Distribution Substation 12.47 kV bus was 0.89 MVA. With all existing and previously approved generation operating, the addition of the 0.5 MW Facility may cause reverse power flow during periods of peak generation.

Voltage regulation for the 74G2 circuit is provided by single phase voltage regulators, as listed in Table 1. The regulator controls will need to be set to "lockforward" for reverse power flow conditions.

4.0 Relay and Protection Review

Control Point performed a protection review of Soveren, Inc, proposed interconnection of a 500 kW PV generator to the Company's 74G2, a 7.2/12.47 kV distribution circuit served from the #74 Westminster Distribution Substation. This review will identify distribution system enhancements that may be necessary to complete the interconnection project and its ability to meet IEEE 1547 Standards and Vermont Public Service Board Rule 5.500 that are applicable for this interconnection.

4.1 Integration with Area EPS Grounding

Per IEEE 1547 Section 4.1.2 Integration with Area EPS grounding, the grounding scheme of the Facility's interconnection shall not cause over-voltages that exceed the rating of the equipment connected to the Area EPS and shall not disrupt the coordination of the ground fault protection on the Area EPS.

As stated in section 2.2 the Facility will interconnect to the 4.8/8.32 kV three-phase, 4-wire, multi-grounded wye, effectively-grounded 74G2 radial circuit from the Westminster Substation. In order to avoid over-voltage on the area EPS during outage conditions, it is required that the proposed DR being interconnected to the 4 wire circuit provide a limit on over-voltages equivalent to an effectively grounded system with respect to the Company circuit.

Effectively grounded, which is grounded through a connection of sufficiently low impedance, is defined as the ratio X_0/X_1 being less than 3 and the ratio R_0/X_1 being less than 1 (IEEE standard 142).

The proposed Soveren, Inc project was modeled using ASPEN OneLiner V11.10. When connected to the area EPS, the Facility appears effectively grounded with an X_0/X_1 ratio of 2.42333 and an R_0/X_1 ratio of 0.31545.

4.2 Fault Current Contributions

Table 10 shows the fault duties at the Westminster Distribution Substation and at the PCC.

Fault Location	Fault Type	Pre-Project Amps	Post- Project Amps	Δ%
12.47 kV Substation Bus	LG	6,065	6,152	1.43
	LLL	4,789	4,970	3.78
12.47 PCC	LG	499	514	3.01
	LLL	521	559	7.29

Table 12: Fault Current Contribution

Post Project fault current contribution was derived by modeling the inverters as a current limited generator, using ASPEN recommended instructions. The analysis was conducted with the synchronous generators off-line.

Soveren, Inc is responsible for ensuring that their equipment is rated to withstand the available fault current.

4.3 Temporary Over-Voltages on Transmission Supply

The possibility of Temporary Over-Voltages on the Transmission Supply is of concern when there is a reverse of power onto the Supply that cannot be dampened during line to ground faults. In screening the project for $3V_0$ protection, it was determined that the minimum bus loading is approximately equal to the connected DG resources. The transmission owner is this interconnection is National Grid. Their protection standards for DG resources will require that $3V_0$ protection be installed at the Westminster Substation. Station modifications will include:

- Installation of three phase 69 kV potential transformers connected wye-ground/wye-ground.
- Digital relay – SEL 351with 59N element active.
- Instrumentation and control wiring

The Developer is responsible for inverter shutdown during ground faults. Over-voltage protection will conform to IEEE 1547, Section 4.2.3. The Project will require a change in overvoltage protection at the substation.

4.4 Temporary Over-Voltage on Distribution System

The maximum generation capacity on the 74G2 exceeds the minimum load on the circuit. This condition can create a TOV in some instances. Because the inverters act as a constant current source, they can create a transient over-voltage event when a switch opens and forces all of the inverter current through a fixed load impedance.

Per IEEE 1547 Section *4.2.3 Voltage, The protection functions of the interconnection system shall detect the phase-to-neutral voltage where the transformer connecting the Local EPS to the Area EPS is a grounded wye-wye configuration*.

The voltages shall be detected at either the PCC or the point of DR connection when any of the following conditions exist:

> *a) The aggregate capacity of DR systems connected to a single PCC is less than or equal to 30 kW.*
>
> *b) The interconnection equipment is certified to pass a non-islanding test for the system to which it is to be connected.*
>
> *c) The aggregate DR capacity is less than 50% of the total Local EPS minimum annual integrated electrical demand for a 15 minute time period, and export of real or reactive power by the DR to the Area EPS is not permitted.*

Voltage range (% of base voltage[a])	Clearing time(s)[b]
$V < 50$	0.16
$50 \leq V < 88$	2.00
$110 < V < 120$	1.00
$V \geq 120$	0.16

[a]Base voltages are the nominal system voltages stated in ANSI C84.1-1995, Table 1.
[b]DR ≤ 30 kW, maximum clearing times; DR > 30kW, default clearing times.

Table 13: IEEE Interconnection system response to abnormal voltages

The inverter manufacturer is UL listed. As such, it will meet these requirements.

To ensure that the Project is disconnected as instantaneously as possible from the EPS during a fault the interconnection requester is responsible to provide and maintain a relayed breaker with per phase overcurrent elements set instantaneously for 125% of rated phase to neutral voltage. In addition, the relay shall be set with 81U, 81O, 27 elements redundant to the inverter protection settings and conforming to IEEE 1547.

If an event occurs with an over-voltage at the PCC exceeding limitations and/or any reported damage of customer equipment, The Company reserves the right to disconnect the Project from the EPS. The developer will be responsible for all associated claims and for mitigation to prevent re-occurrence. In this instance, The Company could require a Direct Transfer Trip (DTT) scheme from all upstream feeder sectionalizing devices to a PCC recloser.

4.5 Isolation Device

Per IEEE 1547 section 4.1.7 Isolation device, when required by the area EPS operating practices, a readily accessible, lockable, visible-break isolation device shall be located between the Area EPS and the DR unit.

The Company will require a Lockable Visible Blade Disconnect to be located on the Company's primary voltage facilities between the Project and the EPS. It is required that the switch be in a location easily accessible to Company personnel at all times. The switch shall have a visible break when open, be rated to interrupt the maximum generator output and be capable of being locked open, tagged and grounded on the Company side by Company personnel.

4.6 Unintentional Islanding

Per IEEE 1547 section 4.4.1 Unintentional Islanding, for an unintentional island in which the DR energizes a portion of the Area EPS through the PCC, the DR interconnection system shall detect the island and cease to energize the Area EPS within two seconds of the formation of an island.

The project was screened for the potential of islanding during abnormal operating conditions. The evaluation was performed at peak, light load, and median load conditions. The screening criteria[2] provide guidelines to determine whether a detailed Anti-Islanding study, which determines the need for Direct Transfer Trip, will be required. The following are the guidelines used to determine this requirement:

1. If there are other PV's on the circuit that utilize a different inverter manufacturer than the proposed PV for this project the inverter Anti-Islanding function may not operate as designed. Therefore, a detailed ANTI ISLANDING STUDY will be required.

2. If Existing or Proposed Reciprocating Generation is greater than 20% of the Total Aggregate Inverter based PV then an ANTI ISLANDING STUDY will be required.

3. If the following Anti Islanding Criteria calculates between 0.99 and 1.01 then an ANTI ISLANDING STUDY is required

$$0.99 \leq \frac{Q_{cap}}{Q_{PV}+Q_{load}} \leq 1.01$$

[2] Screening criteria derived from the Sandia Report on "Suggested Guidelines for Anti-Islanding Screening".

The area EPS will include two 225 kVA synchronous and 321 kW of inverter based photovoltaic generators. The synchronous generators are to be equipped with DTT to clear them from the system during contingency operations. The other inverter based generation on the circuit has sufficient impedance and distance between the POI's, that there is minimal risk of islanding. The pre-existing and previously proposed generators should not present any elevated risk of islanding with the DTT scheme active.

The evaluation indicates that the proposed project does not have the potential to create an island during system outage conditions, refer to Figure 24: Anti-Islanding. A detailed anti-islanding study is not recommended, provided the customer can provide documentation that certifies the inverters are UL 1741-2005/ IEEE1547 compliant

4.7 Direct Transfer Tripping

A direct transfer tripping system, if one is required by either the Interconnecting Customer or by the Company, shall use equipment generally accepted for use by the Company and shall, at the option of the Company, use dual channels.

DTT is not required for this interconnection refer to section 4.6 above

4.8 Surge-Withstand capability

Per IEEE 1547 Section 4.1.8.2 Surge Withstand Performance, the interconnection system shall have the capability to withstand voltage and current surges in accordance with the environments defined in IEEE Standard C62.41.2-2002 or IEEE Standard C37.90.1-2002 as applicable.

4.9 Protection Scheme Assessment

The proposed radial tap at Pole 95, Taglet 38384, is protected by an upstream recloser at Pole 78, Taglet 38337. The proposed design will not require changes to the existing overcurrent protection schemes. The Project is required to provide and maintain a relayed breaker with per phase overcurrent elements set for instantaneous operation at 125% of rated phase to neutral voltage. In addition, the relay shall be set with 81U, 81O, 27 elements redundant to the inverter protection settings and conforming to IEEE 1547. This breaker shall serve to isolate faults occurring within the project footprint.

5.0 Cost Estimate

A description of the interconnection scope is included with the invoice in Appendix C. This cost estimate is in good faith and **does not** include the 32.8% federal tax on Contribution In Aid of Construction (CIAC). At this point in time, GMP believes that customer is not liable for such tax. The customer may choose to consult their own financial experts regarding this and/or to pay the CIAC now for their own reasons. If the customer chooses not to pay the

CIAC now and it is determined in the future that CIAC is due, the customer agrees to pay the CIAC and any interest, penalties, etc. as determined by the proper entity in full.

A second estimate is provided in Appendix C with the Line Extension costs removed. Per GMP tariffs, the customer may hire a contractor to construct the line extension in accordance with GMP standards, at which point GMP would take ownership of the line extension.

If GMP is hired to construct the line extension, all materials, including the generator step up transformers, must be supplied by GMP.

6.0 Conclusion

The project can be allowed to interconnect with certain modifications and additions to the local EPS and the Interconnecting Customer's equipment.

The Company's EPS will require minor modifications before the interconnection can proceed. Specifically, re-framing and anchoring a take-off pole.

A three-phase overhead line extension will be required on private property to connect the PV Facility. This line extension will be done at the Customer's expense per GMP's standards.

The project should not have a negative impact on system voltage, under normal operating conditions. The study suggests that a maximum 1.2% voltage change is possible. A dynamic analysis of flicker indicates the maximum flicker will be in the magnitude of 0.41%. It is not anticipated that other customers will notice the voltage fluctuations.

The study indicates that under normal operation of the 12.47 kV distribution system, the interconnection is effectively grounded when connected to the area EPS in some configurations. The inverter's U.L. listing promises fast response to loss-of-source. Recording instruments will be deployed to verify proper operation. The Customer will be responsible for mitigating any demonstrated over-voltage conditions generated at the PCC and exceeding 125% of the nominal line to neutral voltage.

The POI, at Pole 95, Taglet 38384 Westminster Road will be framed to accommodate a three phase riser with disconnects. The overhead conductors will extend a three phase pole mounted transformer bank. Approximately 1,500 feet of new three phase construction is required.

The interconnection requester is responsible to provide and maintain a relayed breaker with per phase overcurrent elements set for instantaneous operation at 125% of rated phase to neutral voltage. In addition, the relay shall be set with 81U, 81O, 27 elements redundant to the inverter protection settings and conforming to IEEE 1547.

The substation regulator control settings must be reconfigured to lock forward once reverse flow is sensed on the distribution.

Three-phase potential transformers will be required at the Westminster Substation. The PT's will be monitored by a digital relay to provide $3V_0$ protection per the transmission owner's requirements.

A State Electrical Inspector must inspect the Project's electrical system to ensure it complies with the National Electric Code.

Authorization for parallel operation will not be issued without a fully executed Interconnection Agreement, receipt of the necessary insurance documentation, and successful completion of the Company approved witness testing per IEEE 1547 Section 5. This testing shall be coordinated with and witnessed by the Company's representatives.

7.0 Customer Responsibilities

The cost estimate listed in Appendix B does not include any equipment to be owned or maintained by the Soveren, Inc. Such equipment includes, but is not limited to, the PV system and associated protective equipment, the GSU, control and communication cabling between the PCC and the PV/inverter equipment, secondary voltage cables, etc. Also not included are any costs due to third party requirements such as telephone and cable TV make ready costs, etc. Soveren, Inc is also responsible to:

a. Provide copies of the inverter factory test reports certifying compliance with IEEE requirements.
b. Provide a Certificate of Insurance with the signed interconnection agreement. The certificate can be mailed to *Green Mountain Power, Attn: Melinda Humphrey, 67 Merchant's Row, Rutland, VT 05701*.
c. Provide adequate protection to restrict overvoltages from exceeding 125% nominal line to neutral voltage at the PCC during steady state and fault conditions.
d. With payment of the cost estimate in Appendix C, Souveren, Inc is responsible to provide a complete contact list for all contractors involved with the project construction.
e. Provide an updated one-line that shows a relayed breaker with per phase overcurrent elements set for instantaneous operation at 125% of rated phase to neutral voltage. In addition, the relay shall be set with 81U, 81O, 27 elements redundant to the inverter protection settings and conforming to IEEE 1547. The new one-line must be signed and stamped by a Professional Engineer.

8.0 Revision History

Version	Date	Description of Revision
Draft 1.0	11/14/13	First Draft submittal
Final 1.0	11/20/13	Final, awaiting estimate
Final 2.0	11/21/13	Final Submittal

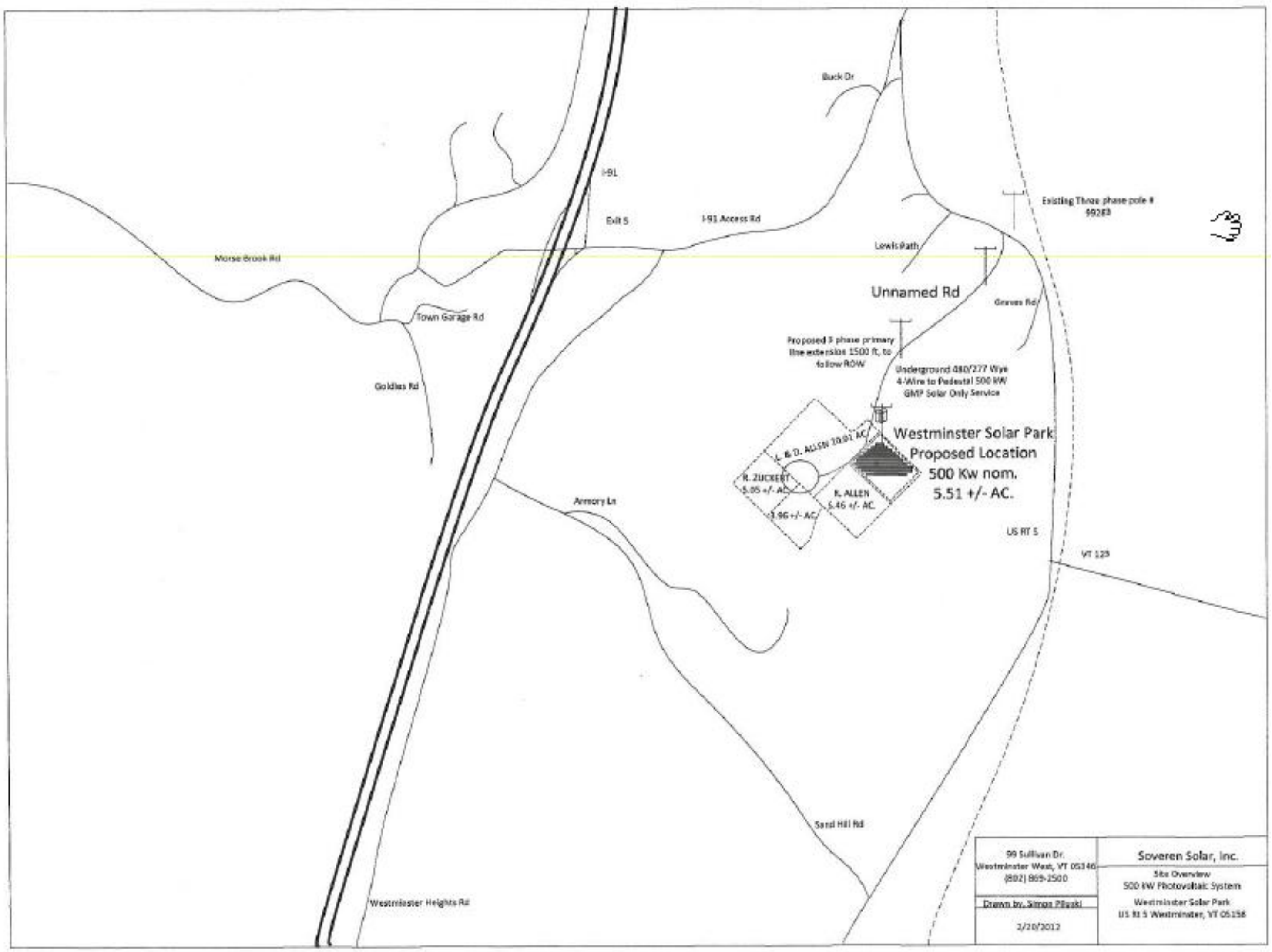

Buck Dr
I-91
Exit 5
I-91 Access Rd
Existing Three phase pole #
99283
Lewis Path
Morse Brook Rd
Unnamed Rd
Graves Rd
Town Garage Rd
Proposed 3 phase primary
line extension 1500 ft, to
follow ROW
Underground 480/277 Wye
4-Wire to Pedestal 500 kW
GMP Solar Only Service
Goldies Rd
Westminster Solar Park
Proposed Location
500 Kw nom.
5.51 +/- AC.
L. & D. ALLEN 10.91 AC
R. ZUCKERT
5.05 +/- AC
K. ALLEN
5.46 +/- AC.
1.96 +/- AC
Armory Ln
US RT 5
VT 123
Sand Hill Rd
Westminster Heights Rd
99 Sullivan Dr.
Westminster West, VT 05346
(802) 869-2500
Drawn by, Simon Pilguski
2/20/2012
Soveren Solar, Inc.
Site Overview
500 kW Photovoltaic System
Westminster Solar Park
US Rt 5 Westminster, VT 05158

Figure 1: Site Diagram

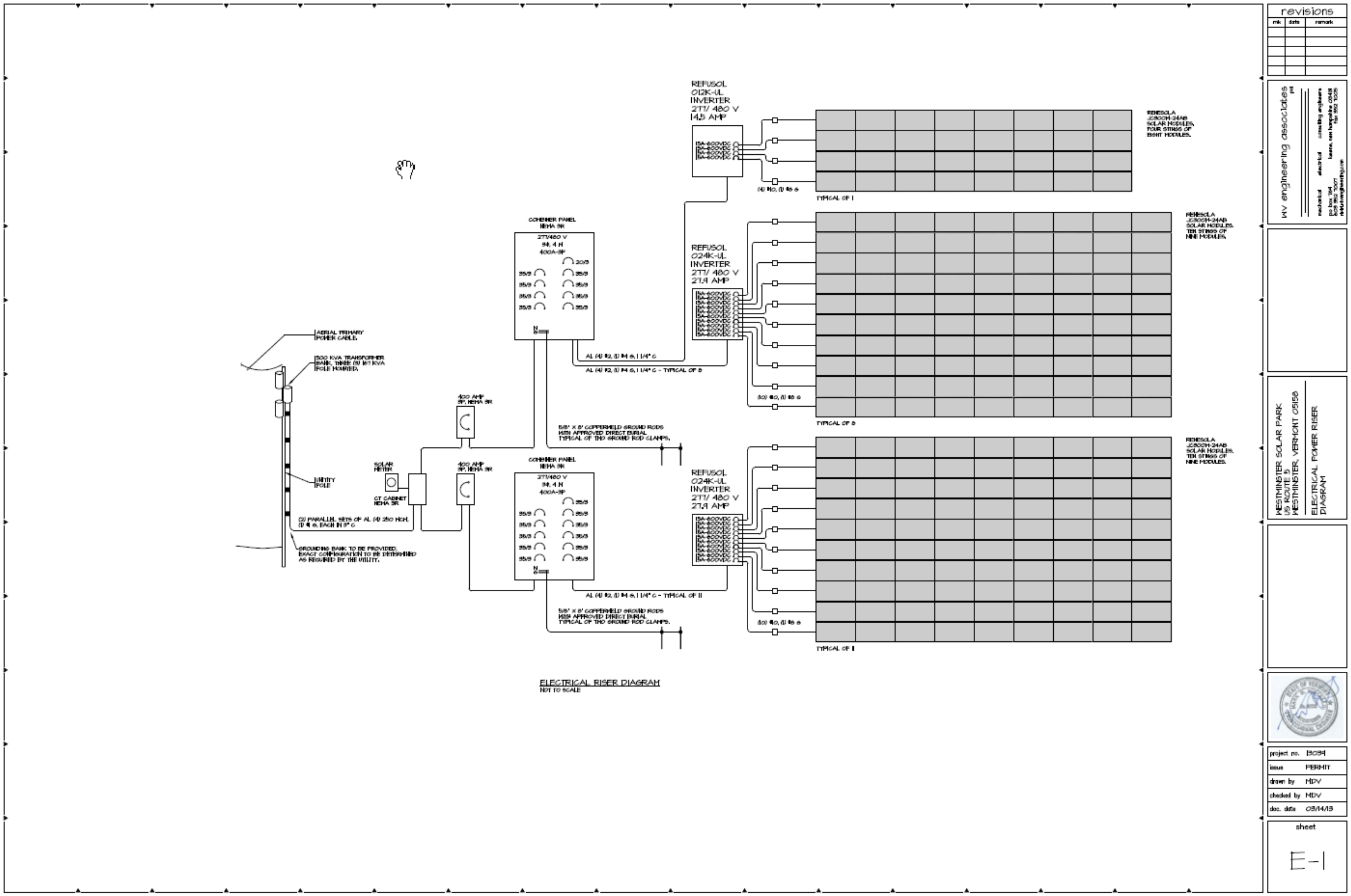
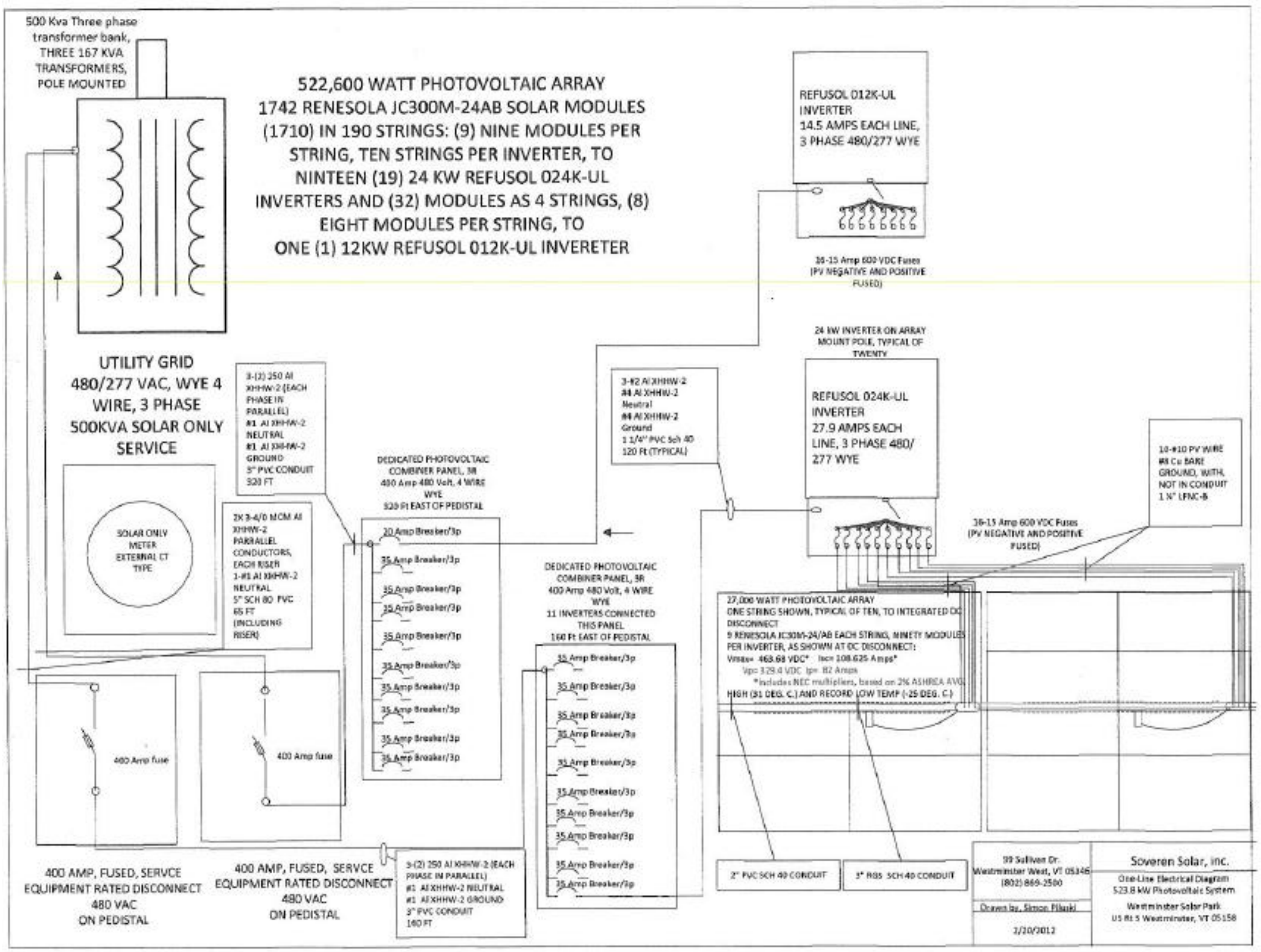


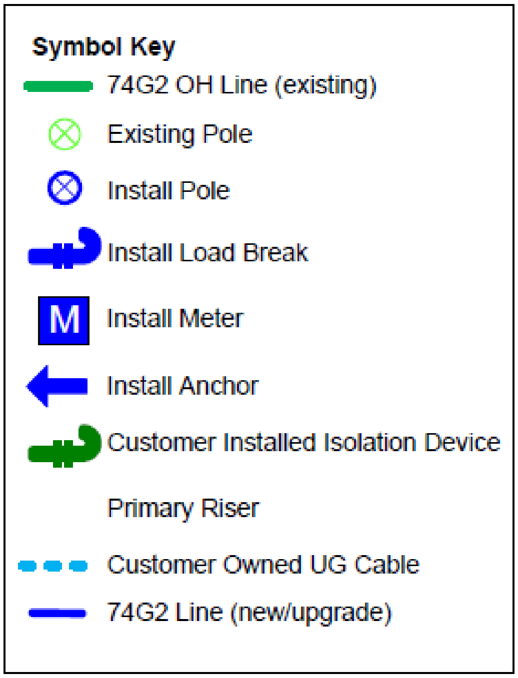
Figure 2: Project One-Line Diagram



500 Kva Three phase transformer bank, THREE 167 KVA TRANSFORMERS, POLE MOUNTED
522,600 WATT PHOTOVOLTAIC ARRAY
1742 RENESOLA JC300M-24AB SOLAR MODULES
(1710) IN 190 STRINGS: (9) NINE MODULES PER STRING, TEN STRINGS PER INVERTER, TO NINTEEN (19) 24 KW REFUSOL 024K-UL INVERTERS AND (32) MODULES AS 4 STRINGS, (8) EIGHT MODULES PER STRING, TO ONE (1) 12KW REFUSOL 012K-UL INVERETER
REFUSOL 012K-UL INVERTER 14.5 AMPS EACH LINE, 3 PHASE 480/277 WYE
16-15 Amp 600 VDC Fuses (PV NEGATIVE AND POSITIVE FUSED)
24 kW INVERTER ON ARRAY MOUNT POLE, TYPICAL OF TWENTY
REFUSOL 024K-UL INVERTER 27.9 AMPS EACH LINE, 3 PHASE 480/ 277 WYE
UTILITY GRID 480/277 VAC, WYE 4 WIRE, 3 PHASE 500KVA SOLAR ONLY SERVICE
3-(2) 250 Al XHHW-2 (EACH PHASE IN PARALLEL) #1 Al XHHW-2 NEUTRAL #1 Al XHHW-2 GROUND 5" PVC CONDUIT 320 FT
3-#2 Al XHHW-2 #4 Al XHHW-2 Neutral #4 Al XHHW-2 Ground 1 1/4" PVC Sch 40 120 Ft (TYPICAL)
10-#10 PV WIRE #8 Cu BARE GROUND, WITH, NOT IN CONDUIT 1 ¼" LFNC-B
DEDICATED PHOTOVOLTAIC COMBINER PANEL, 3R 400 Amp 480 Volt, 4 WIRE WYE 320 Ft EAST OF PEDISTAL
20 Amp Breaker/3p
35 Amp Breaker/3p
SOLAR ONLY METER EXTERNAL CT TYPE
2X 3-4/0 MCM Al XHHW-2 PARRALLEL CONDUCTORS, EACH RISER 1-#1 Al XHHW-2 NEUTRAL 5" SCH 80 PVC 65 FT (INCLUDING RISER)
36-15 Amp 600 VDC Fuses (PV NEGATIVE AND POSITIVE FUSED)
DEDICATED PHOTOVOLTAIC COMBINER PANEL, 3R 400 Amp 480 Volt, 4 WIRE WYE 11 INVERTERS CONNECTED THIS PANEL 160 Ft EAST OF PEDISTAL
27,000 WATT PHOTOVOLTAIC ARRAY
ONE STRING SHOWN, TYPICAL OF TEN, TO INTEGRATED DC DISCONNECT
9 RENESOLA JC300M-24/AB EACH STRING, NINETY MODULES PER INVERTER, AS SHOWN AT DC DISCONNECT:
Vmax= 463.68 VDC* Isc= 108.625 Amps*
Vp= 329.4 VDC Ip= 82 Amps
*includes NEC multipliers, based on 2% ASHREA AVG HIGH (31 DEG. C.) AND RECORD LOW TEMP (-25 DEG. C.)
400 Amp fuse
400 AMP, FUSED, SERVICE EQUIPMENT RATED DISCONNECT 480 VAC ON PEDISTAL
400 AMP, FUSED, SERVCE EQUIPMENT RATED DISCONNECT 480 VAC ON PEDISTAL
3-(2) 250 Al XHHW-2 (EACH PHASE IN PARALLEL) #1 Al XHHW-2 NEUTRAL #1 Al XHHW-2 GROUND 3" PVC CONDUIT 160 FT
2" PVC SCH 40 CONDUIT
3" RGS SCH 40 CONDUIT
99 Sullivan Dr. Westminster West, VT 05346 (802) 869-2500
Drawn by, Simon Pilaski
2/20/2012
Soveren Solar, inc.
One-Line Electrical Diagram
523.8 kW Photovoltaic System
Westminster Solar Park
US Rt 5 Westminster, VT 05158

Figure 3: Project One-line, Panel Connections

Description of Work:
- Frame Pole 38384 for three phase take-off
- Install approximately 10 poles and 1,500 feet of 3-1/C-1/0 Al overhead construction.
- Install Loadbreak Disconnects.



Please Note: The Existing OH line is on the other side of Westminster Rd. The lineEx must make a road crossing. GMP will provide you with a corrected copy.

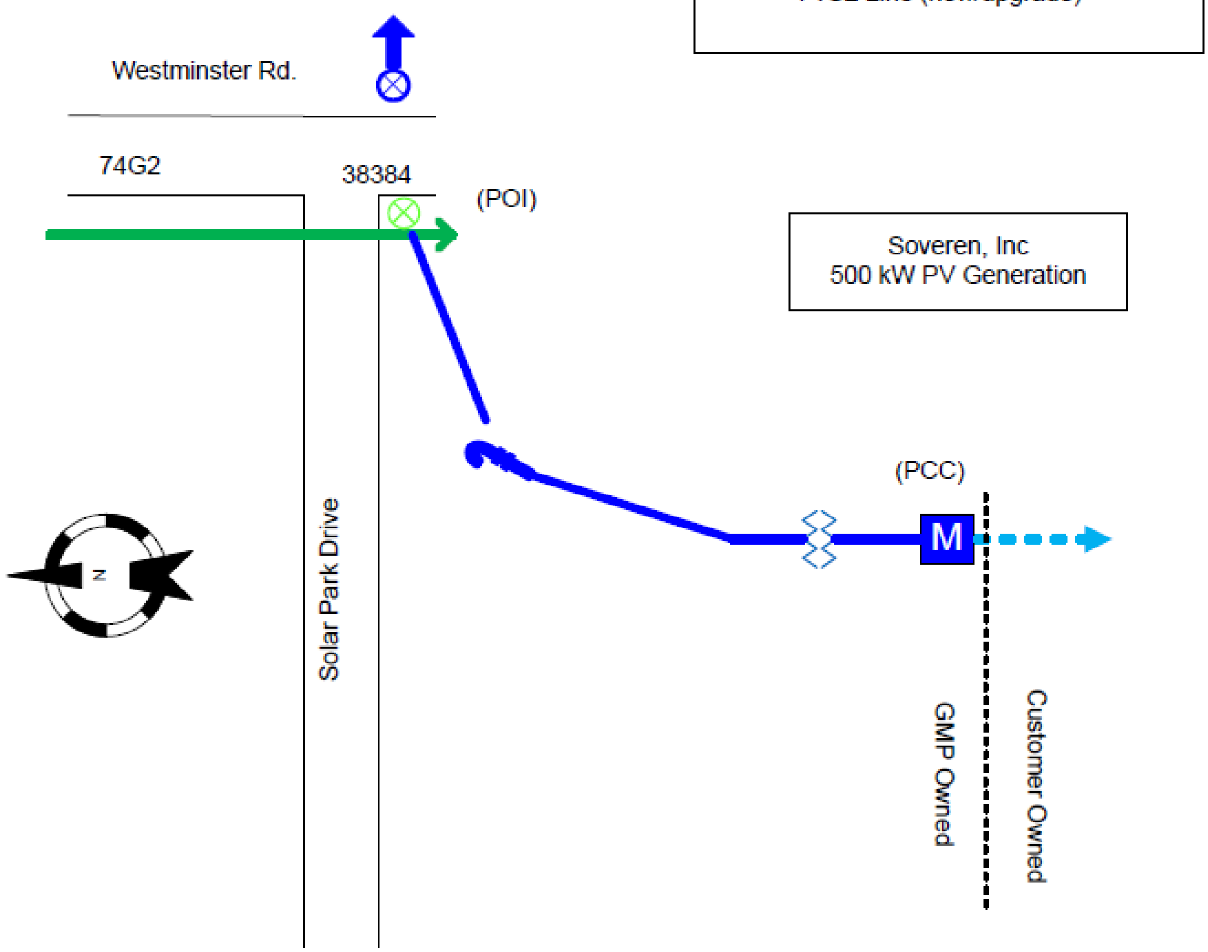


Figure 4: 74G2 Interconnection One-Line

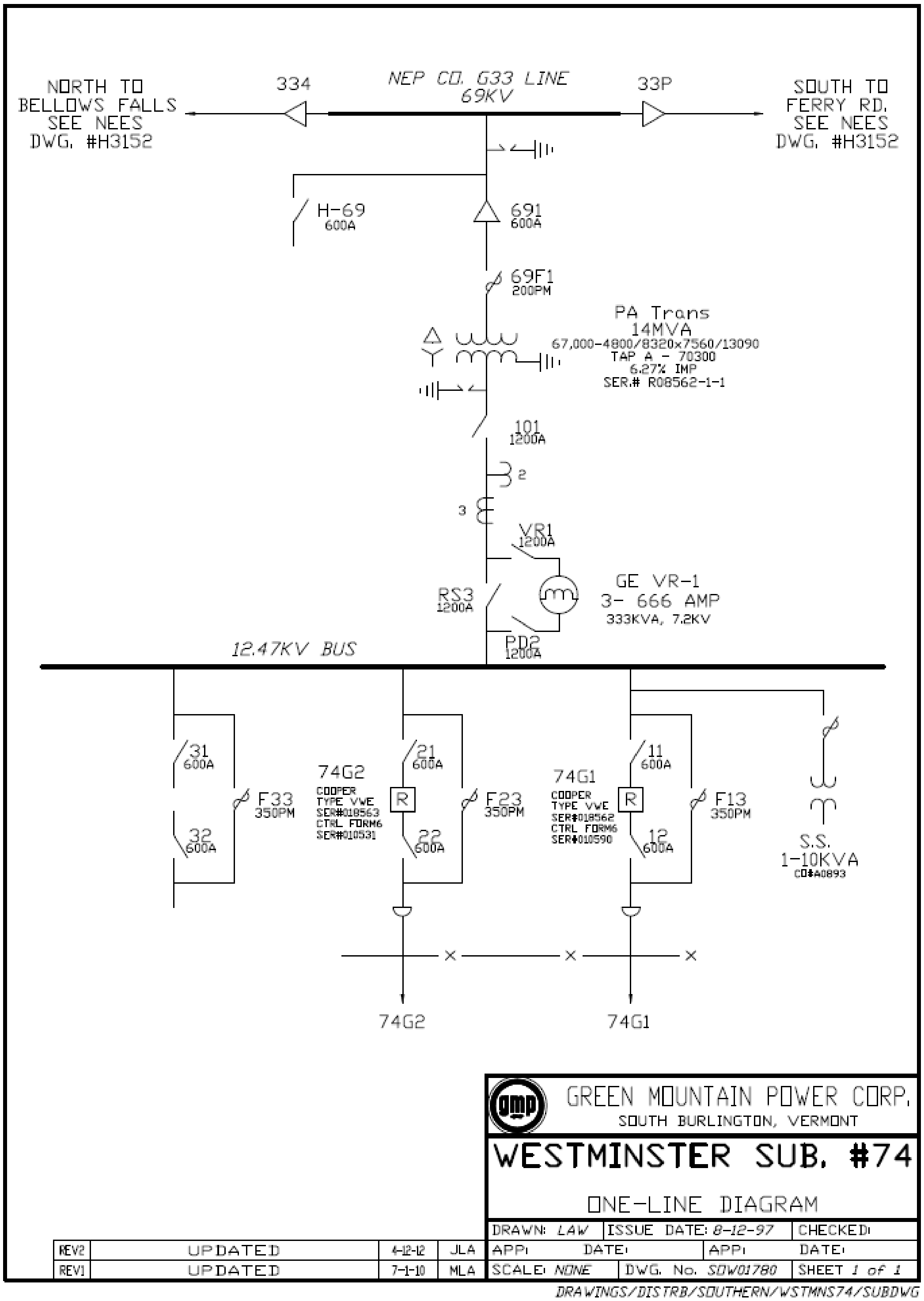


Figure 5: **Westminster One Line**

EXHIBIT A
ONE LINE DIAGRAM
GOODELL 2ND
GENERATOR
11/3/11

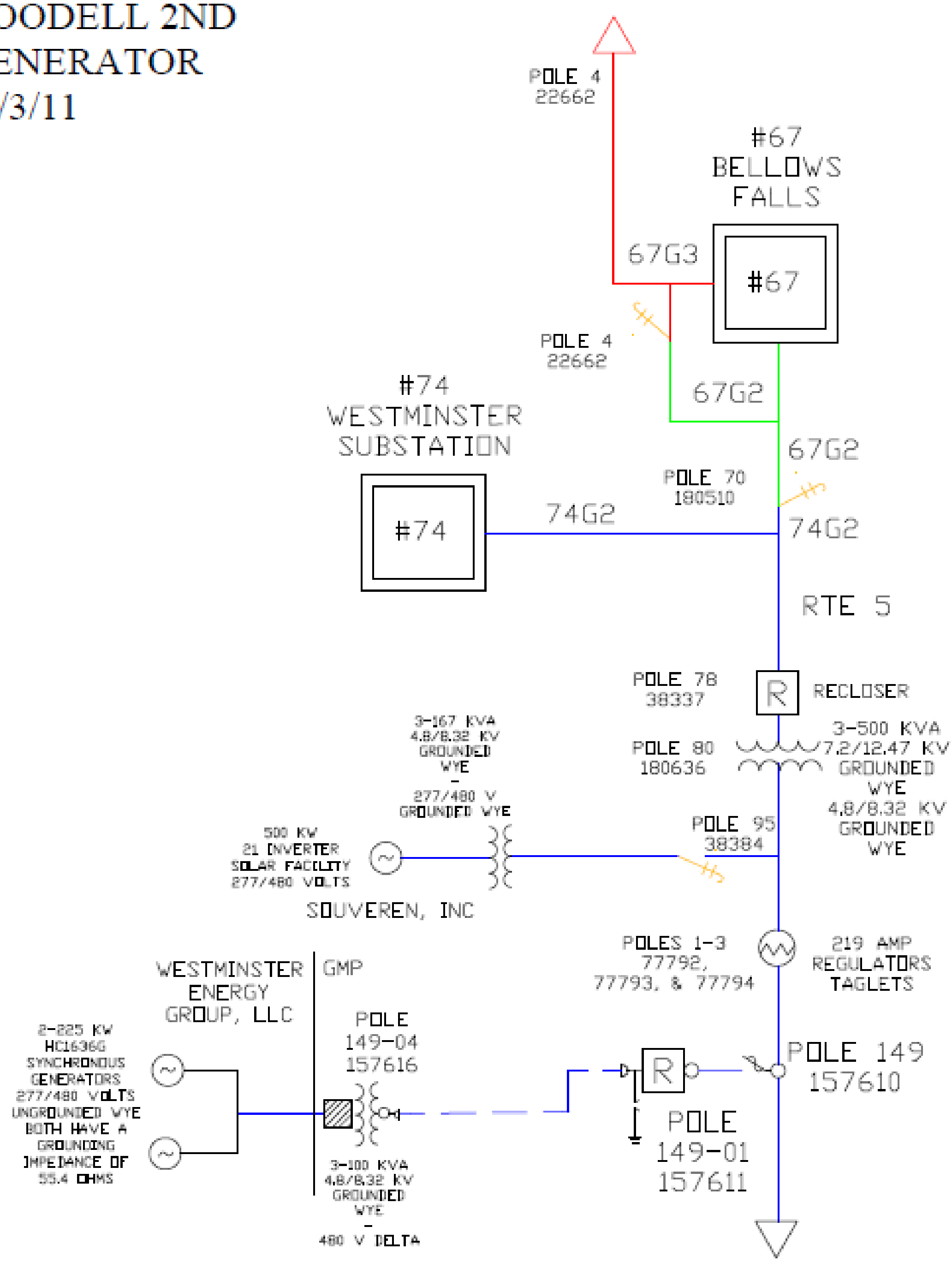


Figure 6: 74G2-67G2 Circuit One-Line

74G2

	Max Load 1.43 MVA @ 99.3 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF Goodell ON															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub - Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR *	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.021	1.024	1.030	98%	-	-	-	1.030	1.031	1.031	1	958	100%
	NA	497	16	1.028	1.030	1.037	100%	0.70%	0.60%	0.70%	1.031	1.031	1.031	7	458	100%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.031	1.034	1.040	99%	1.00%	1.00%	1.00%	1.031	1.032	1.032	-65	463	99%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.024	1.027	1.034	98%	0.30%	0.30%	0.40%	1.030	1.030	1.030	77	463	99%

Figure 7: Max Load Conditions with Goodell On

74G2

	Min Load 0.503 MVA @ 92.5 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF; Goodell ON															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub - Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR *	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.020	1.026	1.027	54%	-	-	-	1.028	1.029	1.029	212	18	8%
	NA	-497	16	1.026	1.032	1.034	100%	0.60%	0.60%	0.70%	1.028	1.029	1.029	244	-474	-89%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.029	1.035	1.037	99%	0.90%	0.90%	1.00%	1.029	1.030	1.030	171	-469	-94%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.023	1.028	1.030	99%	0.30%	0.20%	0.30%	1.028	1.028	1.029	315	-469	-83%

Figure 8: Minimum Load Conditions with Goodell On

74G2																
	Max Load 1.43 MVA @ 99.3% PF lagging - Small PV Sites Operating at Nameplate & 100% PF; Goodell Off															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub - Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.008	1.010	1.018	100%	-	-	-	1.028	1.028	1.029	165	1421	99%
	NA	497	16	1.016	1.018	1.025	100%	0.80%	0.80%	0.70%	1.029	1.029	1.029	156	917	99%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-54	1.019	1.022	1.029	99%	1.10%	1.20%	1.10%	1.029	1.030	1.030	84	922	100%
GEN @ -0.99 PF (importing Vars/Leading)	NA	491	87	1.012	1.015	1.022	98%	0.40%	0.50%	0.40%	1.028	1.028	1.029	227	922	97%

Figure 9: Maximum Load Flow Results with Goodell Off

74G2																
	Min Load 0.503 MVA @ 92.5 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF; Goodell Off															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub – Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.015	1.021	1.023	95%	-	-	-	1.028	1.029	1.029	194	465	92%
	NA	497	16	1.022	1.028	1.030	100%	0.70%	0.70%	0.70%	1.028	1.029	1.029	209	-33	-16%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.026	1.031	1.033	99%	1.10%	1.00%	1.00%	1.029	1.030	1.030	137	-28	-20%
GEN @ -0.99 PF (importing Vars/Leading)	NA	491	87	1.019	1.024	1.026	98%	0.40%	0.30%	0.30%	1.028	1.028	1.029	280	-27	-10%

Figure 10: Minimum Load Flow Results with Goodell Off

74G2 On 67G2

	Max Load 1.55 MVA @ 98.4 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF Goodell ON														
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Bellows Falls Sub - Load Side of Regulators				
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.010	1.018	1.025	99%	-	-	-	1.030	1.030	1.031	206	1526	99%
	NA	497	16	1.020	1.028	1.035	100%	1.00%	1.00%	1.00%	1.031	1.030	1.032	193	1020	98%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.025	1.032	1.039	99%	1.50%	1.40%	1.40%	1.032	1.031	1.032	124	1025	99%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.016	1.023	1.030	98%	0.60%	0.50%	0.50%	1.030	1.030	1.031	268	1026	97%

Figure 11: Maximum Load Flow Results, 74G2 on 67G2; Goodell On

74G2 On 67G2

	Min Load 0.615 MVA @ 92.5 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF; Goodell ON															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Bellows Falls Sub – Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.017	1.021	1.023	52%	-	-	-	1.029	1.029	1.029	391	475	77%
	NA	-497	16	1.025	1.030	1.031	100%	0.80%	0.90%	0.80%	1.030	1.030	1.029	419	-17	-4%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.030	1.034	1.036	99%	1.30%	1.30%	1.30%	1.030	1.030	1.030	342	-13	-4%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.021	1.025	1.027	99%	0.40%	0.40%	0.40%	1.029	1.029	1.029	491	-11	-2%

Figure 12: Minimum Load Flow Results, 74G2 on 67G2; Goodell On

74G2 On 67G2																
	Max Load 2.0 MVA @ 98.4 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF Goodell OFF															
Gen Output	**Switched Capacitor Status**	**GEN Status kW**	**GEN Status kVAR**	**PCC**							**Bellows Falls Sub - Load Side of Regulators**					
				V PU A	**V PU B**	**V PU C**	**PF**	**Delta VA**	**Delta VB**	**Delta VC**	**V PU A**	**V PU B**	**V PU C**	**KVAR***	**KW**	**PF**
GEN @ 1.0 PF	NA	**OFF**	**OFF**	1.010	1.011	1.021	100%	-	-	-	1.032	1.032	1.033	357	1986	98%
	NA	497	16	1.018	1.019	1.029	100%	0.80%	0.80%	0.80%	1.033	1.032	1.034	343	1480	97%
***GEN @ +0.99 PF (exporting Vars/Lagging)**	NA	492	-54	1.022	1.022	1.032	99%	1.20%	1.10%	1.10%	1.034	1.033	1.034	272	1485	98%
GEN @ -0.99 PF (importing Vars/Leading)	NA	491	87	1.015	1.015	1.025	98%	0.50%	0.40%	0.40%	1.032	1.031	1.033	416	1485	96%

Figure 13: Maximum Load Flow Results, 74G2 on 67G2; Goodell Off

74G2 On 67G2																
	Min Load 0.996 MVA @ 92.5 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF; Goodell OFF															
Gen Output	**Switched Capacitor Status**	**GEN Status kW**	**GEN Status kVAR**	**PCC**							**Bellows Falls Sub – Load Side of Regulators**					
				V PU A	**V PU B**	**V PU C**	**PF**	**Delta VA**	**Delta VB**	**Delta VC**	**V PU A**	**V PU B**	**V PU C**	**KVAR***	**KW**	**PF**
GEN @ 1.0 PF	NA	**OFF**	**OFF**	1.020	1.022	1.026	95%	-	-	-	1.033	1.033	1.033	365	923	93%
	NA	497	16	1.027	1.029	1.027	100%	0.70%	0.70%	0.10%	1.033	1.033	1.033	379	425	75%
***GEN @ +0.99 PF (exporting Vars/Lagging)**	NA	492	-55	1.030	1.033	1.036	99%	1.00%	1.10%	1.00%	1.034	1.034	1.034	307	430	81%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.023	1.026	1.023	98%	0.30%	0.40%	-0.30%	1.033	1.033	1.032	450	430	69%

Figure 14: Minimum Load Flow Results, 74G2 on 67G2; Goodell Off

67G2 On 74G2

	Max Load 1.55 MVA @ 98.4 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF Goodell ON														
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub - Load Side of Regulators				
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.010	1.018	1.025	99%	-	-	-	1.030	1.030	1.031	206	1526	99%
	NA	497	16	1.020	1.028	1.035	100%	1.00%	1.00%	1.00%	1.031	1.030	1.032	193	1020	98%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.025	1.032	1.039	99%	1.50%	1.40%	1.40%	1.032	1.031	1.032	124	1025	99%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.016	1.023	1.030	98%	0.60%	0.50%	0.50%	1.030	1.030	1.031	268	1026	97%

Figure 15: Maximum Load Flow Results, 67G2 on 74G2; Goodell On

67G2 On 74G2

	Min Load 0.615 MVA @ 92.5 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF; Goodell ON															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub – Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.017	1.021	1.023	52%	-	-	-	1.029	1.029	1.029	391	475	77%
	NA	-497	16	1.025	1.030	1.031	100%	0.80%	0.90%	0.80%	1.030	1.030	1.029	419	-17	-4%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.030	1.034	1.036	99%	1.30%	1.30%	1.30%	1.030	1.030	1.030	342	-13	-4%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.021	1.025	1.027	99%	0.40%	0.40%	0.40%	1.029	1.029	1.029	491	-11	-2%

Figure 16: Minimum Load Flow Results, 67G2 on 74G2; Goodell On

67G2 On 74G2

	Max Load 2.0 MVA @ 98.4 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF Goodell OFF															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub - Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.010	1.011	1.021	100%	-	-	-	1.032	1.032	1.033	357	1986	98%
	NA	497	16	1.018	1.019	1.029	100%	0.80%	0.80%	0.80%	1.033	1.032	1.034	343	1480	97%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-54	1.022	1.022	1.032	99%	1.20%	1.10%	1.10%	1.034	1.033	1.034	272	1485	98%
GEN @ -0.99 PF (importing Vars/Leading)	NA	491	87	1.015	1.015	1.025	98%	0.50%	0.40%	0.40%	1.032	1.031	1.033	416	1485	96%

Figure 17: Maximum Load Flow Results, 67G2 on 74G2; Goodell Off

67G2 On 74G2

	Min Load 0.996 MVA @ 92.5 % PF lagging - Small PV Sites Operating at Nameplate & 100% PF; Goodell OFF															
Gen Output	Switched Capacitor Status	GEN Status kW	GEN Status kVAR	PCC							Westminster Sub – Load Side of Regulators					
				V PU A	V PU B	V PU C	PF	Delta VA	Delta VB	Delta VC	V PU A	V PU B	V PU C	KVAR*	KW	PF
GEN @ 1.0 PF	NA	OFF	OFF	1.020	1.022	1.026	95%	-	-	-	1.033	1.033	1.033	365	923	93%
	NA	497	16	1.027	1.029	1.027	100%	0.70%	0.70%	0.10%	1.033	1.033	1.033	379	425	75%
*GEN @ +0.99 PF (exporting Vars/Lagging)	NA	492	-55	1.030	1.033	1.036	99%	1.00%	1.10%	1.00%	1.034	1.034	1.034	307	430	81%
GEN @ -0.99 PF (importing Vars/Leading)	NA	492	87	1.023	1.026	1.023	98%	0.30%	0.40%	- 0.30%	1.033	1.033	1.032	450	430	69%

Figure 18: Minimum Load Flow Results, 67G2 on 74G2; Goodell Off

Flicker Data Summary

PCC

Minute Nodal Analysis

	Times Above Borderline of Irritation/Minute	Times Above Borderline of Visibility/Minute
A Phase	0	0
B Phase	0	0
C Phase	0	0

Maximum % Change (V/s) in Sample		
A Phase	Max Delta Va	*0.25%*
B Phase	Max Delta Vb	*0.33%*
C Phase	Max Delta Vc	*0.24%*

Maximum % Change in a rolling 60 Second Sample

		% Change	Flicker/Minute
A Phase	%Va Average Fluctuation	0.00%	*0*
B Phase	%Vb Average Fluctuation	0.00%	*0*
C Phase	%Vc Average Fluctuation	0.00%	*0*

Maximum Observed Voltage	Volts
A Phase	121.9
B Phase	122.4
C Phase	123

Maximum Fluctuations per Minute

		Flicker/Minute	% Change
A Phase	Max Per Minute Fluctuation	0	*0.00%*
B Phase	Max Per Minute Fluctuation	0	*0.00%*
C Phase	Max Per Minute Fluctuation	0	*0.00%*

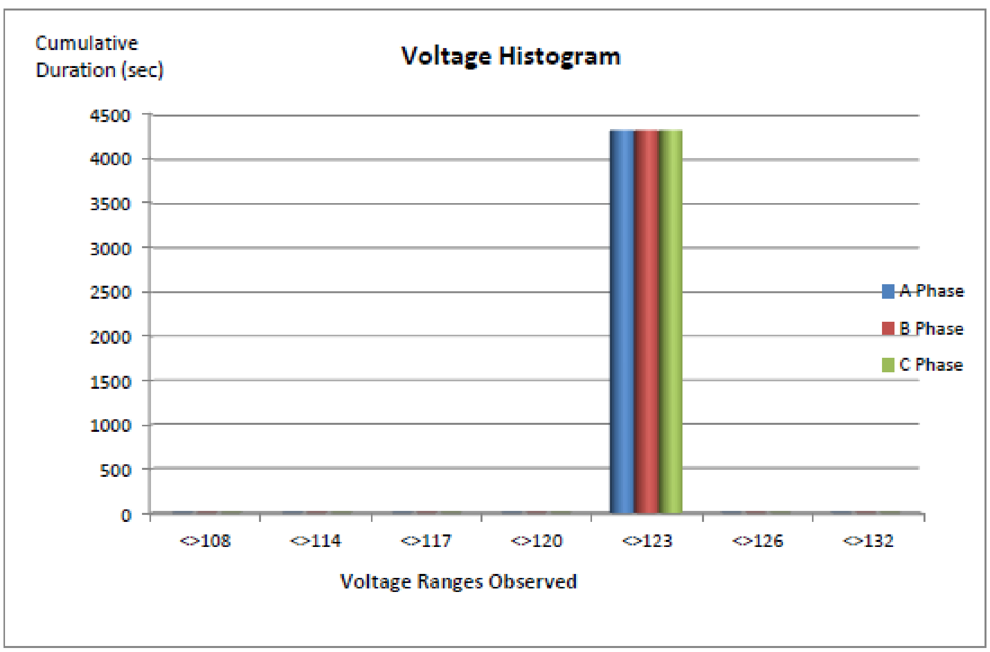


Figure 19: PCC Flicker Summary @ 100% PF

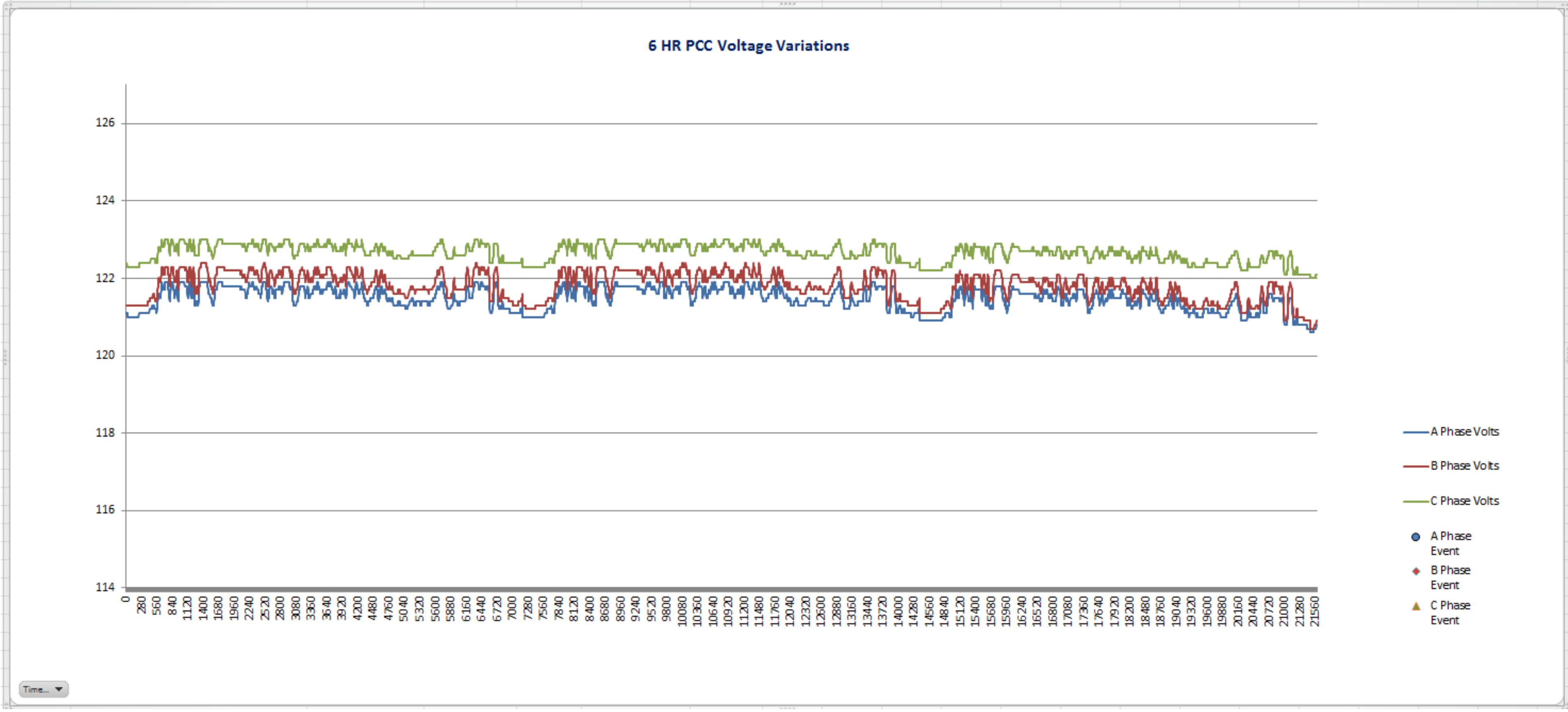
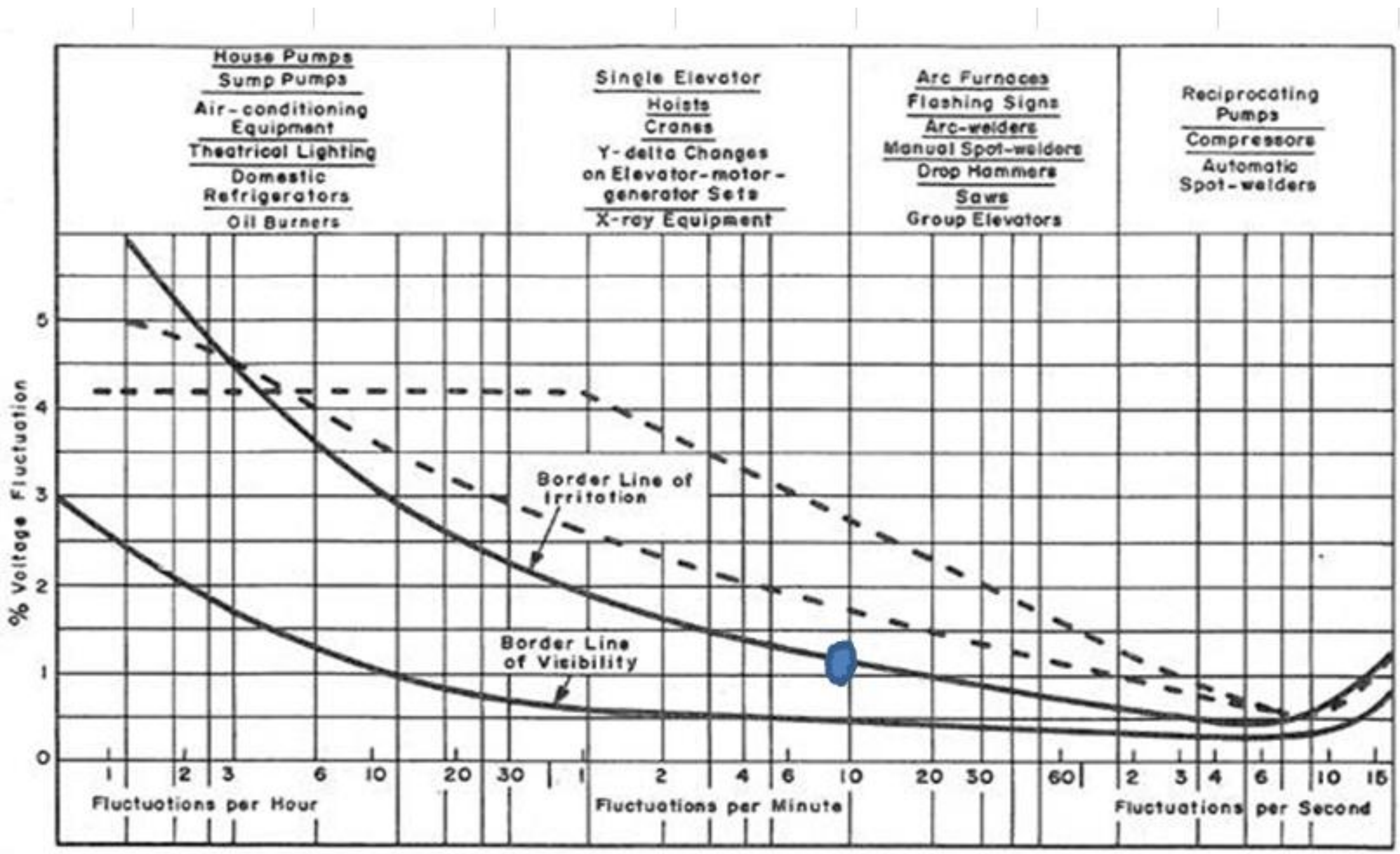


Figure 20: PCC Voltage Profile @ 100% PF



Solid Lines composite curves of voltage flicker studies by General Electric Company, *General Electric Review* August 1925; Kansas City Power & Light Company, *Electrical World*, May 19, 1934; T. & D. Committee, EEI, October 24, 1934, Chicago; Detroit Edison Company; West Pennsylvania Power Company; Public Service Company of Northern Illinois.

Dotted Lines voltage flicker allowed by two utilities, references *Electrical World* November 3, 1958 and June 26, 1961.

Figure 21: GE Flicker Chart

Flicker Data Summary

PCC

Minute Nodal Analysis

	Times Above Borderline of Irritation/Minute	Times Above Borderline of Visibility/Minute
A Phase	0	0
B Phase	0	0
C Phase	0	0

Maximum % Change (V/s) in Sample		
A Phase	**Max Delta Va**	*0.25%*
B Phase	**Max Delta Vb**	*0.33%*
C Phase	**Max Delta Vc**	*0.24%*

Maximum % Change in a rolling 60 Second Sample

		% Change	Flicker/Minute
A Phase	%Va Average Fluctuation	**0.00%**	***0***
B Phase	%Vb Average Fluctuation	**0.00%**	***0***
C Phase	%Vc Average Fluctuation	**0.00%**	***0***

Maximum Observed Voltage	Volts
A Phase	**121.9**
B Phase	**122.4**
C Phase	**123**

Maximum Fluctuations per Minute

		Flicker/Minute	% Change
A Phase	**Max Per Minute Fluctuation**	**0**	*0.00%*
B Phase	**Max Per Minute Fluctuation**	**0**	*0.00%*
C Phase	**Max Per Minute Fluctuation**	**0**	*0.00%*

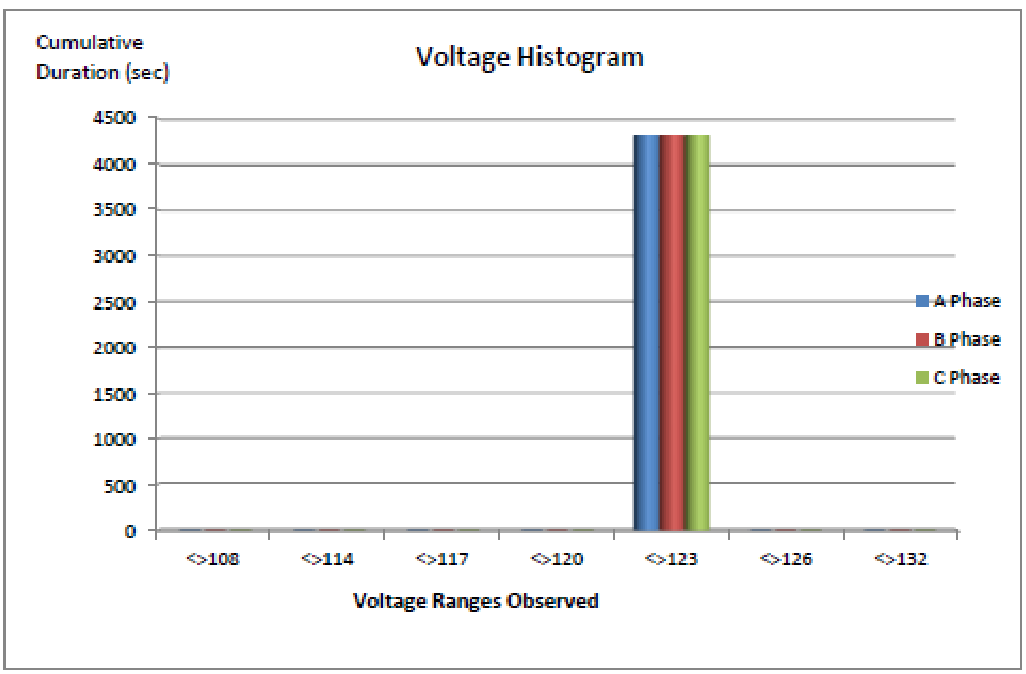


Figure 22: PCC Flicker Results @ +99% PF

Flicker Data Summary
PCC

Minute Nodal Analysis

	Times Above Borderline of Irritation/Minute	Times Above Borderline of Visibility/Minute
A Phase	0	0
B Phase	0	0
C Phase	0	0

Maximum % Change (V/s) in Sample		
A Phase	Max Delta Va	*0.25%*
B Phase	Max Delta Vb	*0.41%*
C Phase	Max Delta Vc	*0.16%*

Maximum % Change in a rolling 60 Second Sample

		% Change	Flicker/Minute
A Phase	%Va Average Fluctuation	0.00%	*0*
B Phase	%Vb Average Fluctuation	0.41%	*1*
C Phase	%Vc Average Fluctuation	0.00%	*0*

Maximum Observed Voltage	Volts
A Phase	122.8
B Phase	123.2
C Phase	123.8

Maximum Fluctuations per Minute

		Flicker/Minute	% Change
A Phase	Max Per Minute Fluctuation	0	*0.00%*
B Phase	Max Per Minute Fluctuation	1	*0.41%*
C Phase	Max Per Minute Fluctuation	0	*0.00%*

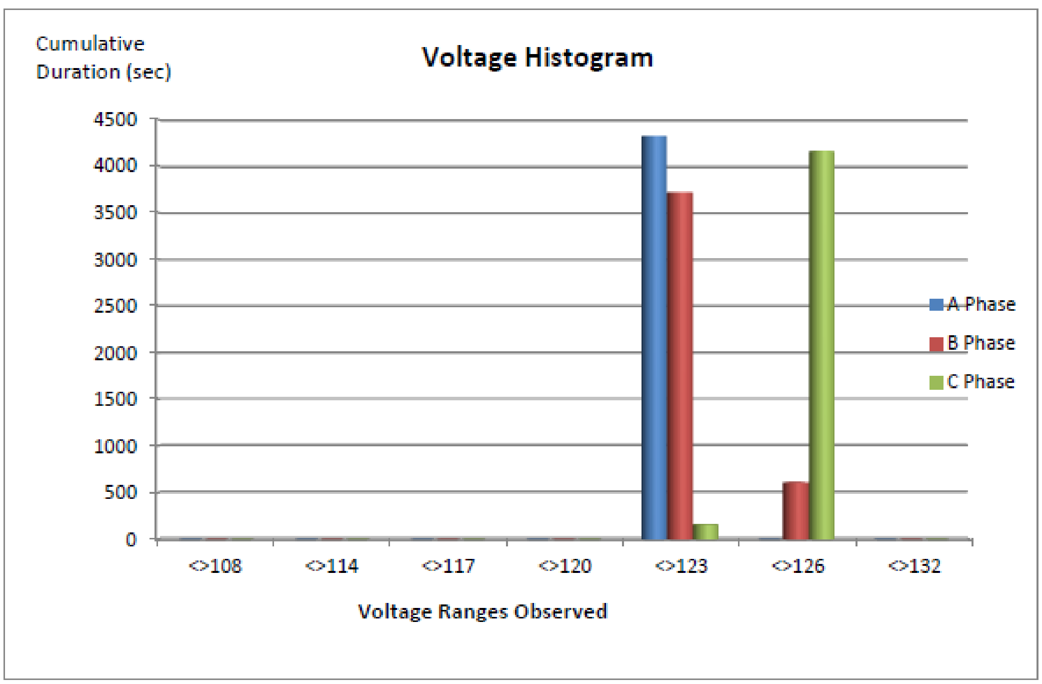


Figure 23: PCC Flicker Results at -99% PF

This Sheet is to be used when Circuit True Power (kW) and Reactive Power (kVAR) are known.
All values in **BLACK BOLD** are User Entered.
All values in **RED BOLD** are calculated.

Is there a Possible Load Match	Y
Are there other PV's on proposed circuit a with different Manufacturer than this Project.	**Y**
Are there Reciprocating Generators on this Circuit, if yes move to #3 if no move to #4	**N**
Reciprocating Generator Rating	**0**
Total Aggregate PV on Circuit	**821**
Circuit Power Factor	**0.922900667**
Circuit Apparent Power	**503.8462067**
Circuit True Power	**465**
Circuit Reactive Power	**194**
Total Aggregate Line Capacitors **Qcap**	**500**
PV System Reactive Output **Qpv**	**0**
Circuit Load Reactive Part **Qload**	694
ANTI ISLANDING CRITERIA	**0.720461095**
	ANTI ISLANDING STUDY NOT REQUIRED

Criteria Explanation

1. If there are other PV's on the circuit that utilize a different inverter manufacturer than the proposed PV for this project than the inverter Anti-Islanding function may not operate as designed. Therefore, a detailed ANTI ISLANDING STUDY will be required.
2. If Existing or Proposed Reciprocating Generation is great than 20% of the Total Aggregate Inverter based PV then an ANTI ISLANDING STUDY will be required.
3. If the Anti Islanding Criteria calculates between 0.99 and 1.01 then an ANTI ISLANDING STUDY is required.

Figure 24: Anti-Islanding Analysis

Appendix A

Received 4/1/13 MH

Vermont Public Service Board Standard Application Form to Rule 5.500

STANDARD APPLICATION FOR INTERCONNECTION OF GENERATION RESOURCES IN PARALLEL TO THE ELECTRIC SYSTEM OF: Green Mountain Power
(Name of Utility)

Shaded area to be completed by Interconnecting Utility

Interconnecting Utility: ____
Interconnecting Utility's Designated Contact Person: ____
Interconnecting Utility's Address: ____
Interconnecting Utility's Fax Number: ____
Interconnecting Utility's E-Mail Address: ____
Substation ____ Circuit ____ ☐ Distribution ☐ Transmission

Preamble and Instructions:
An owner of a generation resource who requests interconnection to a State regulated distribution or transmission facility must submit an application to the Interconnecting Utility. An application is accepted as complete when it provides all applicable information required. There is a **$300.00** Application fee that must be submitted to the Interconnecting Utility along with the Application.

Section 1. Applicant Information

A. Legal Name of Interconnecting Applicant (or, if an Individual, Individual's Name)

Name: Soveren, Inc
Mailing Address: 101 Sullivan Drive
City: Putney State: VT Zip Code: 05346
Facility Location: Westminster Business Park, Westminster VT 05159 - Parcel # 8-73-3-1
(Facility E-911 address)
Telephone (Daytime): (802) 869 - 2500 (Alternate): (802) 869 - 1819
Fax Number: ____ E-Mail Address: maria@soverensolar.com

B. Alternative Contact Information (if different from Applicant)

Contact Name: ____
Contact Title: ____
Address: ____

____
Telephone (Daytime): (___) ___ - ____ (Alternate): (___) ___ - ____
Fax Number: ____ E-Mail Address: ____

C. Will the Generation Resource be used for any of the following:

To supply power to internal loads (other than the station itself)? ☐ Yes ☒ No
To participate in the SPEED Standard Offer Program? ☐ Yes ☒ No

D. For generators installed at locations with existing electric service:

(Local Electric Service Provider*) ____
(Existing Account Number*) ____

E. Additional Information

Requested Point of Interconnection: Pole #99283
Interconnection Applicant's requested in-service date: Fall 2013

Section 2. Generator Qualifications
All data applicable only to the generator facility, NOT the necessary interconnection facilities

Energy source:
☒ Solar ☐ Wind ☐ Hydro ☐ Diesel ☐ Natural Gas ☐ Fuel Oil ☐ Other____________
(state type)

Type of Generator:
☐ Synchronous ☐ Induction ☐ Inverter (DC Generator or Solar)

Generator Manufacturer: RefuSol
Generator Model Name & Number: 024-K-UL (19) & 012-K-UL (1) (24k=23.2 rated)
Generator Nameplate Rating: 452.8 kW (Total if multiple units)
Generator Nameplate kVAR: 1 (field adj 0.95i...1...0.95c)
Applicant or Customer-Site Load: None kW (if none, so state)
Typical Reactive Load (if known)____________
Maximum Physical Export Capability Requested: 500 kW

Section 3. Generator Technical Information

a. *Induction or Synchronous Generators (for rotating machines)*

Rated Power Factor Leading: ____________
Rated Power Factor Lagging: ____________
List of Adjustable Set points for the protective equipment or software: ____________
Direct Axis Transient Reactance, X'd: ____________ P.U.
Direct Axis Unsaturated Transient Reactance, X'di: ____________ P.U.
Direct Axis Subtransient Reactance, X"d: ____________ P.U.
Generator Saturation Constant (1.0): ____________
Generation Saturation Constant (1.2): ____________
Negative Sequence Reactance: ____________ P.U.
Zero Sequence Reactance: ____________ P.U.
kVA Base: ____________
RPM Frequency: ____________
*Field Volts ____________
*Field Amperes ____________
*Motoring Power (kW) ____________
*Neutral Grounding Resistor (If Applicable) ____________
*I22t or K (Heating Time Constant) ____________
*Rotor Resistance ____________
*Stator Resistance *Stator Reactance ____________
*Rotor Reactance*Magnetizing Reactance ____________
*Short Circuit Reactance ____________
*Exciting Current ____________
*Temperature Rise ____________
*Frame Size *Design Letter ____________
*Reactive Power Required In Vars (No Load) ____________
*Reactive Power Required In Vars (Full Load) ____________
*Total Rotating Inertia, H: ____________ Per Unit on kVA Base

Appendix A

b. For Wind Turbines

Total Number of turbines to be interconnected pursuant to this application:______________

Height to blade tip : ______________ Blade diameter __________

Quantity of Turbines ______________ Size (KW) Each _________

c. For Solar or DC sources

Inverter Manufacturer, Model Name & Number : REFUsol 024k-ul (@19), REFUsol 012k-ul (@1)

Quantity of Inverters 20 Size KW Each 23.2 & 12

Panel Manufacturer, Model Name & Number: Renesola JC300M-2M/A6

Quantity of panels 1742 Size (Watts) Each 300

Inverters are UL1741 listed ☒ Yes ☐ No

Section 4. Interconnection Equipment Technical Data *(for generation over 20 KW)*

Will a transformer (GSU) be used between the generator and the point of interconnection? ☐ Yes ☒ No

Will the transformer be provided by Interconnection Applicant? ☐ Yes ☒ No

Is the Transformer three phase? ☒ Yes ☐ No

Is the Transformer pad mounted or Pole mounted? ☐ Pad ☒ Pole

Transformer Size: 500 kVA Impedance: _________ % on _________ kVA Base

Interconnection Voltage (GSU Data)

Transformer Primary: ________ Volts ☐ Single Phase ☐ Delta ☐ Wye ☐ Grounded Wye

Transformer Secondary: 480 Volts ☐ Single Phase ☐ Delta ☐ Wye ☒ Grounded Wye

Other Transformer information ____

Interconnecting Circuit Breaker (if applicable):

Manufacturer: Mersen Type: Fuse TRS/RKS Load Rating: (2) 400 Interrupting Rating: 200 k AIR AC

Trip Speed: _________

Current Transformer (CT) Data (if applicable):

Manufacturer: ____________ Type: _________ Accuracy Class: ________ Ratio: _______

Potential Transformer Data (if applicable):

Manufacturer: ____________ Type: _________ Accuracy Class: ________ Ratio: _______

Section 5. General Site Information

a. Enclose copy of site electrical One-Line Diagrams showing the configuration of all generating facility equipment, current and potential circuits, and protection and control schemes.
[Note: This one-line diagram must be signed and stamped by a licensed Professional Engineer if the generating facility is larger than 150 kW.]
b. Enclose copy of any site documentation that describes and details the operation of the protection and control schemes.
c. Enclose copies of schematic drawings for all protection and control circuits, relay current circuits, relay potential circuits, and alarm/monitoring circuits (if applicable).
d. Enclose copy of any site documentation that indicates the precise physical location of the proposed generating facility (e.g. USGS topographic map or other diagram).

Section 6. Check List: Required Fee and Enclosures

Is an application fee enclosed? [x] Yes
Are One-Line Diagrams enclosed? [x] Yes
Is site documentation enclosed? [x] Yes
Are schematic drawings enclosed? [x] Yes [ ] No
Are site maps enclosed? [x] Yes

Section 7. Applicant Signature

I hereby certify that, to the best of my knowledge, all the information provided in the Interconnection Application is true and correct.

Signature of Applicant: Marc Arnold Date: 3/18/13

Appendix B

Rule 5.500 Fast Track Analysis for Soveren Inc.

For a 500 kW Solar array to be located on Solar Park Road in Westminster, Vermont

Green Mountain Power

Pam Allen

Date: 5/10/13

SECTION 1 – Project Description, Rule 5.500 Notes, Fast Track Scope

SECTION 2 – Fast Track Analysis

Appendix B

Appendix B

SECTION 1

Project Description, Rule 5.500 Notes, Fast Track Scope

Project Description: Sovern Inc. is proposing a 500 kW AC Solar net metering project (the "Project") to be located off of a feed to be taken at approximately taglet 38384 Pole 95 Route 5 in Westminster, Vermont. This will be fed by Green Mountain Power's ("GMP") 74G2 distribution circuit which is fed by the #74 Westminster Substation. The 74G2 is a 7.2/12.47 kV Grounded Wye circuit with approximately 772 kW of other distributed generation projects installed and proposed which will be included in the analysis as part of the aggregate Distributed Generation. The proposed project is at a location that currently does not have any power available. A line extension of approximately 1,500 feet will need to be built to the Project. The proposed Project is also located downstream of a transformer bank which transforms the voltage from 7.2/12.47 kV to 4.8/8.32 kV.

Are there any existing relevant studies?

Yes, there are two previous System Impact Studies that have done on this circuit, both at the same location. The most recent study will be shared with this Project owner per Rule 5.500. It should also be noted that the Project is connecting beyond a step down transformer bank that is planned to be removed in the future. The addition of this Project may necessitate the acceleration of the removal of the bank which could have some cost impact on the Project.

Are there any other existing materials?

No.

Modeling Assumptions:

The generator step up transformer will be grounded wye-grounded wye. Our current understanding is that the chosen inverter is connected ineffectively grounded with respect to the GMP system. A grounding bank will be required to connect the Project. No grounding bank was specified in the Application. So to give the Project sufficient time to design the grounding bank but to facilitate the quick and efficient of the studies needed for the Project the developer will be allowed to deliver the grounding bank design to GMP before the completion of the System Impact Study which takes 60 business days. For the purposes of the Fast Track the Project was modeled as having a grounded wye-delta transformer to simulate worst case fault current contribution from the Project. It is assumed that any grounding bank design would have less of a fault contribution, but without better data this quantity is unknown.

It is assumed that the transformer would have a 3.5% impedance based on the transformer kVA which is 500.

The 1,500 foot line extension will be built to GMP's efficiency standard and have 1/0AAAC conductor.

SECTION 2

Fast Track Review

Criteria that are not passed will be colored in red.

1) **The Interconnection Requester's proposed Generation Resource meets the applicable codes and standards of Section 5.510 or is certified equipment package under Section 5.511.**

   The Inverters proposed for the project are REFUSOL 024k-ul (@19), REFUsol 012k-ul (@1) these inverters possess UL1741 certification.

2) **The proposed interconnection point is not at transmission voltage (i.e. not over 23 kV line to line or 13.28 line to neutral).**

   The generation resource is connecting to the 74G2 which has a voltage level of 7.2/12.47 kV grounded wye; this is not a transmission line. However, the location where this Project will be interconnecting is currently stepped down to 4.8/8.32 kV.

3) **For interconnection to a Radial Feeder, the aggregated generation, including the proposed Generation Resource, on the circuit will not exceed 15% of the line section annual peak load as most recently measured at the substation. A line section is that portion of a distribution system connected to a customer bounded by Automatic Disconnect Devices or the end of the distribution line.**

   The closest in line protective device to this Project is a recloser located at taglet 38337. The estimated peak load at this device is roughly 1,123 kVA, 926 kW, 58, 60 and 34 Amps on each phase.

   Total aggregate installed and proposed generation downstream of the recloser is 1,007 kVA. This is roughly 90% of the line section annual peak load of the recloser at 38337.

   The next upstream protective device is the circuit recloser which had a peak load of 1,195 kVA in July of 2012, total aggregate generation proposed and installed on the circuit is about 1,071 kVA. This is approximately 90% of the annual line section peak load.

4) **The aggregated generation, including the proposed Generation Resource, on a distribution circuit will not contribute more than 10% to the distribution circuit's maximum fault current at the point on the high voltage (primary) level nearest the proposed interconnection point.**

   The maximum available line to ground fault current without any generation contribution taken into account at the end of the proposed line extension is estimated to be 1,079 Amps three phase ("LLL") and 1,026 Amps Line-to-Ground ("LG"). With all generation existing and proposed taken into account the fault current at the end of the proposed line extension increases to 1,161 Amps LLL and 1,338 LG, this is an increase of about 7.6% and 30%.

Appendix B

Fast Track Scope : The Fast Track Analysis is meant to be a coarse screen that allows easily connectible projects to proceed to an Interconnection Agreement without having to do any additional Studies. If future studies are required this Analysis can be used to pin point areas of additional study.

5) **The aggregated generation, including the proposed Generation Resources, on a distribution circuit will not cause any distribution protective devices and equipment (including, but not limited to, substation breakers, fuse cutouts, and line reclosers), or customer equipment on the system to exceed 85% of the short-circuit interrupting capability; nor is the Generation Resource proposed for a circuit that already exceeds 85% of the short-circuit interrupting capability.**

   The closest in line protective device to this Project is a recloser located at taglet 38337, this device has a 12 kA interrupting rating.

   It is not currently possible to determine the fault current contribution from this Project since it will require a grounding bank. However, it is not expected that a grounding bank or even a secondary delta on the Project transformer would reach 85% of the interrupting rating of the recloser.

6) **For interconnection of a proposed single-phase or effectively-grounded three-phase Generation Resource where the primary distribution System is three-phase, four-wire, the Generation Resource will be connected line-to-neutral. For interconnection of a proposed single-phase or three-phase Generation Resource where the primary distribution system is three-phase, three-wire, the Generation Resource will be connected line-to-line.**

   The 74G2 is a three phase, four wire, system, otherwise known as "grounded wye". The proposed Project will be connected to GMP via a grounded wye-grounded wye transformer. However, the Project's inverters will not have a continuous low impedance bond to the system neutral, this means that essentially this Project is connecting three phase three wire to GMP, this creates an ineffectively grounded source with respect to GMP. We will require a grounding transformer be designed by the Project and evaluated by GMP, to ensure that GMP can maintain power quality on the GMP system.

7) **Voltage drop due to starting the proposed generator is within acceptable limits, meaning that inrush current, due to starting the proposed Generation Resource up to once per hour, is not greater than 3% of the available fault current. Voltage drop due to starting the proposed Generation Resource more than once per hour meets a tighter inrush-current tolerance, to be determined by the Interconnecting Utility.**

   Inrush current for a solar facility is not going to be as significant an indicator of voltage flicker as it would be for a rotating generator. A simple test monitoring the voltage before and after startup will be used instead. At the Point of Interconnection ("POI"), prior to any generation being on-line at peak the voltages are approximately 119, 118.8, and 120.8 volts. With all generation on including the proposed project, and the regulator taps locked, the voltages are estimated to be 119.7, 119.7, and 121.3 volts. The worst case out of all of these shows a voltage flicker of 0.76%, this is a fairly small change and not a concern for GMP, since this would be *acceptable under the old GE Flicker curve with around twenty such events in an hour, it would seem a fairly low probability that the project would provoke such excursions more frequently.*

8) **For any single Generation Resource, the available utility short circuit current at the Point of Interconnection divided by the rated output current of the Generation Resource is no less than:**

   a) 50 for Generation Resource of less than 100 kW;
   b) 40 for Generation Resources from 100 kw to less than 500 kW; and
   c) **20 for Generation Resources equal to or greater than 500 kW.**

   The line-to-ground fault current at the POI on the primary side is 1,026.

   *The per phase amps of the project are 500 kW/(3*4.8 kV) = 34.7*

   1,026/34.7 = 29.57

9) **Aggregate generation, including the Generation Resource, on a circuit will not exceed 2 MVA in an area where there are known or posted transient stability limitations to generating units located in the general electrical vicinity (e.g. three or four busses from the point of interconnection).**

   There are no transient stability limitations that GMP is aware of.

10) **No System Upgrades, in excess of limited preparation that do not necessitate a Facilities Study, are required to facilitate the interconnection of the Generation Resource.**

    A 1,500' line extension will be required for the Project, which will necessitate some significant design time.

    The Project shall be required to either provide a grounding bank design to GMP before the completion of the System Impact Study. The grounding bank will require some additional evaluation.

    It's quite possible that the aggregate generation will end up pushing back on the National Grid transmission line that feeds the #74 substation. This will require a conversation with them and possibly an additional study or material may be required.

11) **For interconnection of the proposed Generation Resource to the load side of spot network protectors, the proposed Generation Resource utilizes inverter-based equipment and aggregate generation, including proposed Generation Resource, will not exceed the smaller of 5% of a spot network's maximum load or 50 kW. Synchronous generators cannot be connected to a secondary network.**

    There are no spot networks on the GMP system.

12) If the Generation Resource is to be connected on a shared, single-phase secondary, aggregate generation capacity on the shared secondary, including the proposed generation, will not exceed 20 kVA.

Not Applicable. This project is three phase.

13) If the Generation Resource is single-phased and is to be interconnected on a center tap neutral of a 240 volts service, its addition will not create an imbalance between the two side of the 240 volt service of more than 20% of the service transformer nameplate.

Not Applicable. This project is three phase.

SECTION 3

Fast Track Summary

The project has not passed some criteria in the Fast Track Review. As a result a System Impact Study is required for a further in-depth analysis for the proposed generation resource using the information gathered in this Fast Track Analysis as a guide to target specific areas of interests. The failed criteria are shown below with a brief explanation of what they necessitate in terms of study:

> Criteria 3 shows that there is close to a 1:1 load to generation ratio not only at the line recloser but at the circuit recloser. This is a transient overvoltage concern that can be addressed by better understanding the inverter clearing time when it senses a voltage of more than 1.2 pu. Voltage levels and voltage flicker should also be thoroughly reviewed at low loads to ensure that the stepdown transformer with its impedance does not "choke" the generation flow to the point where it raises voltages above the ANSI limits or exacerbates flicker.
>
> Criteria 4 & 6 indicate that the circuit protection will need to be fully reviewed once the grounding bank design has been provided.
>
> Criteria 10 shows that there is a significant amount of line construction, a protection study may be required, and there is a possibility for involvement with the transmission provider for the #74 substation, these items will necessitate a Facilities Study.

Other items that should be carefully reviewed in the course of a System Impact Study that are not flagged here:

Transmission – It has come to our attention recently that as more and more generation connects to our system the more the greater system starts to see an impact. A review will be done in the System Impact Study to see if further analysis needs to be done on the transmission system that this substation connects to.

Arc Flash – An analysis of the increasing fault current will be done to verify the circuit's arc flash category remains under 2, per company safety policy. It may also be necessary to review the categories for the Essex Substation and the transmission lines feeding it. If the category increases GMP and/or the developer may need to take steps to mitigate the hazard.

Feeder Backup – The 74G2 plays a key role for feeder backup for the #67 Bellows Falls Substation. Protection and voltage analysis should be done with this project taken into account.

Load Rejection Overvoltage – This issue stems from when there is less than a 1:1 generation to load ratio present on the circuit, which will be the case here. A review of how quickly the inverter can clear for a voltage over 1.2 pu when the generator is isolated with load less than the current output will be necessary. It is recommended that the Developer contact their inverter manufacture prior to the start of the System Impact Study to get this test data.

Appendix C

Green Mountain Power Corporation
163 Acorn Lane
Colchester, VT 05446-6611

Invoice

Project Tile:	**Westminster Solar SIS Estimate**
Project Scope:	**Project is the Westminster Business Park Solar array being installed by Soveren Inc. - To connect the proposed array a 7 pole line extension will needed, a secondary metering package will need to be put in, the substation regulators will have to have the settings revised to handle reverse flow, and a set of 69 kV PT's must be installed at the #74 Westminster Substation to prevent a GFOV event on the National Grid G-33 line. This estimate also includes the cost difference between a bank of 10 kVA transformers (the minimum size put in for a three phase load) and a bank of 167 kVA transformers (the size required by the generator). Secondary riser to be supplied by customer, customer connect fee included.**
Oracle Project #:	**132462**
Submitted By:	**Pam Allen/Deb Wood/Joe Adorno/Metering**
Date:	**11/25/13**

Payment Net 30 Days

Area	Hours	Dollars
Engineering	50.0	$6,430.29
Materials	-	$34,805.84
Pole Work	81.5	$8,424.39
Wire Work - Overhead	79.4	$8,207.39
Wire Work - Underground	3.0	$310.13
Travel Time / Other	50.3	$0.00
Sub-Contractors / Services	-	$91,248.68
Substation	4.0	$409.84
Removal	-	$0.00
Total Project Costs	268.2	$149,836.56

Customer Contribution Percentage	100%
Customer Contribution Amount (Total Project Costs x Customer Contribution Percentage)	**$149,836.56**
GMP Tax Surcharge Rate	0.00%
Tax Surcharge on Customer Contribution Amount (Customer Contribution Amount x GMP Tax Surcharge Rate)	**$0.00**
Total Amount Due From Customer	**$149,836.56**

Appendix C

The estimate below excludes the Line Extension costs.

Green Mountain Power Corporation
163 Acorn Lane
Colchester, VT 05446-6611

Invoice

Project Tile:	**Westminster Solar SIS Estimate**
Project Scope:	**Project is the Westminster Business Park Solar array being installed by Soveren Inc. - To connect the proposed array a 7 pole line extension will needed, a secondary metering package will need to be put in, the substation regulators will have to have the settings revised to handle reverse flow, and a set of 69 kV PT's must be installed at the #74 Westminster Substation to prevent a GFOV event on the National Grid G-33 line. This estimate does not include the line extension or the transformers, it assumes that the line-ex is built and all equipment is procured to GMP specifications and then turned over to GMP at the conclusion of construction.**
Oracle Project #:	**132462**
Submitted By:	**Pam Allen/Deb Wood/Joe Adorno/Metering**
Date:	**11/25/13**

Payment Net 30 Days

Area	Hours	Dollars
Engineering	50.0	$6,430.29
Materials	-	$446.63
Pole Work	-	$0.00
Wire Work - Overhead	6.0	$620.28
Wire Work - Underground	-	$0.00
Travel Time / Other	13.8	$0.00
Sub-Contractors / Services	-	$91,197.79
Substation	4.0	$409.84
Removal	-	$0.00
Total Project Costs	73.8	$99,104.83

Customer Contribution Percentage	100%
Customer Contribution Amount (Total Project Costs x Customer Contribution Percentage)	**$99,104.83**
GMP Tax Surcharge Rate	0.00%
Tax Surcharge on Customer Contribution Amount (Customer Contribution Amount x GMP Tax Surcharge Rate)	**$0.00**
Total Amount Due From Customer	**$99,104.83**